US010172652B2

(12) **United States Patent**
Woolley et al.

(10) **Patent No.: US 10,172,652 B2**
(45) **Date of Patent: Jan. 8, 2019**

(54) **METHOD AND APPARATUS FOR PERFORMING SPINAL SURGERY**

(71) Applicant: **NuVasive, Inc.**, San Diego, CA (US)

(72) Inventors: **Troy B Woolley**, Erie, CO (US); **Nathan Lovell**, Oceanside, CA (US); **Michael Serra**, San Diego, CA (US); **Mark Peterson**, Central Point, OR (US)

(73) Assignee: **NuVasive, Inc.**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 34 days.

(21) Appl. No.: **15/394,156**

(22) Filed: **Dec. 29, 2016**

(65) **Prior Publication Data**

US 2017/0105770 A1 Apr. 20, 2017

Related U.S. Application Data

(60) Division of application No. 14/029,724, filed on Sep. 17, 2013, now Pat. No. 9,554,833, which is a continuation of application No. 13/204,583, filed on Aug. 5, 2011, now Pat. No. 8,535,320, which is a continuation of application No. 12/927,415, filed on Nov. 10, 2010, now Pat. No. 8,357,184.

(60) Provisional application No. 61/259,825, filed on Nov. 10, 2009.

(51) **Int. Cl.**

A61B 1/32	(2006.01)
A61B 17/70	(2006.01)
A61B 17/02	(2006.01)

(52) **U.S. Cl.**
CPC ***A61B 17/7077*** (2013.01); ***A61B 1/32*** (2013.01); ***A61B 17/0206*** (2013.01); ***A61B 17/7076*** (2013.01); *A61B 2017/0256* (2013.01)

(58) **Field of Classification Search**
CPC ... A61B 17/7074–17/708; A61B 17/02; A61B 17/0206; A61B 17/025; A61B 2017/0256
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

186,637	A	1/1877	Tanner
1,223,812	A	4/1917	Listiak
1,456,116	A	5/1923	Bessesen
1,520,832	A	12/1924	McConnell
2,807,259	A	9/1957	Guerriero

(Continued)

FOREIGN PATENT DOCUMENTS

CN	201341901	11/2009
CN	201537102	8/2010

(Continued)

OTHER PUBLICATIONS

Deutsch and Musacchio "Minimally invasive transforaminal lumbar interbody fusion with unilateral pedicle screw fixation" Neurosurg Focus, 2006 20(3): E10, 5 pages.

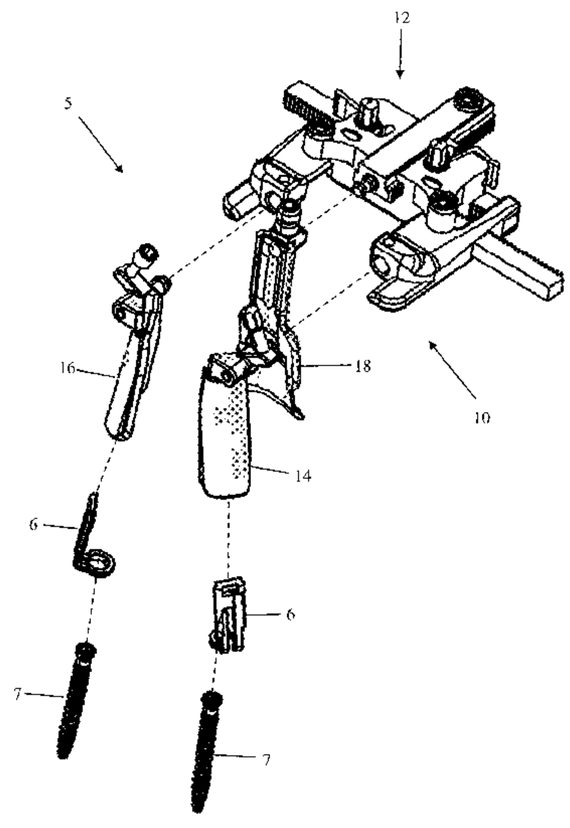
(Continued)

Primary Examiner — Jacqueline Johanas
(74) *Attorney, Agent, or Firm* — NuVasive, Inc.

(57) **ABSTRACT**

Implants, instruments, and methods for performing surgical procedures on the spine, including one or more of creating an operative corridor to the spine, delivering implants to the spine, fusing one or more segments of the spine, and fixing one or more segments of the spine.

21 Claims, 51 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

3,030,948	A		4/1962	Loeffler
3,364,919	A		1/1968	Hunnicutt
3,383,769	A		5/1968	Davis
3,384,077	A		5/1968	Gauthier
3,509,873	A		5/1970	Karlin et al.
3,522,799	A		8/1970	Gauthier
3,724,449	A		4/1973	Gauthier
3,749,088	A		7/1973	Kolhmann
3,795,981	A		3/1974	Franklin et al.
3,965,890	A		6/1976	Gauthier
4,116,232	A		9/1978	Rabban
4,156,424	A		5/1979	Burgin
4,165,746	A		8/1979	Burgin
4,566,466	A		1/1986	Ripple et al.
4,686,972	A		8/1987	Kurland
4,702,230	A		10/1987	Pelta
4,733,657	A	*	3/1988	Kluger A61B 17/66 606/57
4,747,394	A		5/1988	Watanabe
4,747,395	A		5/1988	Brief
4,817,587	A		4/1989	Janese
4,829,985	A		5/1989	Couetil
4,852,552	A		8/1989	Chaux
4,877,020	A		10/1989	Vich
4,881,525	A		11/1989	Williams
4,934,352	A		6/1990	Sullivan
4,957,495	A	*	9/1990	Kluger A61B 17/7014 606/258
5,052,373	A		10/1991	Michelson
5,339,801	A		8/1994	Poloyko
5,400,774	A		3/1995	Villalta et al.
5,417,230	A		5/1995	Wood
5,431,658	A		7/1995	Moskovich
5,512,038	A		4/1996	O'Neal
5,609,593	A		3/1997	Errico et al.
5,649,931	A		7/1997	Bryant
5,728,046	A		3/1998	Mayer et al.
5,733,290	A		3/1998	McCue
5,746,743	A		5/1998	Greenberg
5,755,660	A		5/1998	Tyagi
5,755,732	A		5/1998	Green et al.
5,772,583	A		6/1998	Wright
5,782,830	A		7/1998	Farris
5,795,291	A		8/1998	Koros et al.
5,797,909	A		8/1998	Michelson
5,846,192	A		12/1998	Teixido
5,882,298	A		3/1999	Sharratt
5,890,271	A		4/1999	Bromley
5,893,831	A		4/1999	Koros et al.
5,902,233	A		5/1999	Farley
5,928,139	A		7/1999	Koros et al.
5,931,777	A		8/1999	Sava
5,944,658	A		8/1999	Koros
5,967,972	A		10/1999	Santilli
5,984,865	A		11/1999	Farley
5,993,385	A		11/1999	Johnston
6,042,540	A		3/2000	Johnston
6,042,542	A		3/2000	Koros
6,096,038	A		8/2000	Michelson
6,132,370	A		10/2000	Furnish
6,139,493	A		10/2000	Koros
6,159,215	A		12/2000	Urbahns et al.
6,189,422	B1		2/2001	Stihl
6,206,826	B1		3/2001	Mathews
6,224,545	B1		5/2001	Cocchia
6,241,729	B1		6/2001	Estes
6,244,141	B1		6/2001	Han
6,280,442	B1		8/2001	Barker
6,296,609	B1		10/2001	Brau
6,319,257	B1		11/2001	Carignan et al.
6,322,500	B1		12/2001	Ellefson
6,340,345	B1		1/2002	Lees
6,416,405	B1		7/2002	Brau
6,447,443	B1		9/2002	Keogh
6,454,773	B1		9/2002	Sherman
6,478,800	B1		11/2002	Fraser et al.
6,506,151	B2		1/2003	Estes
6,524,238	B2		2/2003	Velikaris
6,551,242	B1		4/2003	Furnish
6,559,240	B2		5/2003	Hsu
6,599,240	B2		7/2003	Puchovsky et al.
6,599,292	B1		7/2003	Ray
6,623,485	B2		9/2003	Doubler
6,632,238	B2		10/2003	Ginn et al.
6,660,004	B2		12/2003	Barker
6,675,805	B1		1/2004	Graether
6,692,434	B2		2/2004	Ritland
6,698,054	B2		2/2004	Furnish
6,733,444	B2		5/2004	Phillips
6,749,613	B1		6/2004	Conchy et al.
6,802,844	B2		10/2004	Ferree
6,835,196	B2		12/2004	Biederman
6,857,343	B1		2/2005	Easterbrooks
6,860,850	B2		3/2005	Phillips
6,869,398	B2		3/2005	Obenchain et al.
6,887,197	B2		5/2005	Phillips
6,887,198	B2		5/2005	Phillips
6,918,911	B2		7/2005	Biedermann et al.
6,929,606	B2		8/2005	Ritland
6,945,933	B2		9/2005	Branch
6,951,538	B2		10/2005	Ritland
6,964,666	B2		11/2005	Jackson
6,997,086	B1		2/2006	Graham
7,001,333	B2		2/2006	Hamel
7,011,658	B2		3/2006	Young
7,014,608	B2		3/2006	Larson
7,029,472	B1		4/2006	Fortin
7,108,698	B2		9/2006	Robbins
7,147,599	B2		12/2006	Phillips
7,150,714	B2		12/2006	Myles
7,166,073	B2		1/2007	Ritland
7,182,729	B2		2/2007	Abdelgany
7,207,949	B2		4/2007	Miles et al.
7,214,186	B2		5/2007	Ritland
7,235,048	B2		6/2007	Rein
7,250,052	B2		7/2007	Landry et al.
7,318,817	B2		1/2008	Hamada
7,374,534	B2		5/2008	Dalton
7,396,328	B2		7/2008	Penenberg
7,455,639	B2		11/2008	Ritland
7,473,223	B2		1/2009	Fetzer
7,537,565	B2		5/2009	Bass
7,569,014	B2		8/2009	Bass
7,582,058	B1		9/2009	Miles et al.
7,588,537	B2		9/2009	Bass
7,588,593	B2		9/2009	Aferzon
7,654,954	B1		2/2010	Phillips
7,686,809	B2		3/2010	Triplett et al.
7,691,057	B2		4/2010	Miles et al.
7,722,618	B2		5/2010	Estes
7,753,844	B2		7/2010	Sharratt
7,758,501	B2		7/2010	Frasier
7,819,801	B2		10/2010	Miles et al.
7,846,093	B2		12/2010	Gorek et al.
7,846,167	B2		12/2010	Garcia et al.
7,850,608	B2		12/2010	Hamada
7,905,840	B2		3/2011	Pimenta
7,909,829	B2		3/2011	Patel
7,909,848	B2		3/2011	Patel
7,918,792	B2		4/2011	Drzyzga et al.
7,927,337	B2		4/2011	Keller
7,931,589	B2		4/2011	Cohen
7,935,053	B2		5/2011	Karpowiez
7,946,982	B2		5/2011	Hamada
7,959,564	B2		6/2011	Ritland
7,981,031	B2		7/2011	Frasier
8,043,343	B2		10/2011	Miller et al.
8,062,217	B2		11/2011	Boucher
8,066,710	B2		11/2011	Estes
8,100,828	B2		1/2012	Frey et al.
8,167,887	B2		5/2012	McLean
8,372,081	B1		2/2013	Schafer et al.
8,460,306	B2		6/2013	Schaffran et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,535,320	B2 *	9/2013	Woolley	A61B 17/0206 600/210
8,603,094	B2	12/2013	Walker et al.	
8,636,655	B1 *	1/2014	Childs	A61B 17/0206 600/219
8,764,806	B2	7/2014	Abdou	
8,974,381	B1	3/2015	Lovell	
9,050,146	B2 *	6/2015	Woolley	A61B 17/0206
9,393,044	B2 *	7/2016	Masson	A61B 17/7077
9,414,828	B2 *	8/2016	Abidin	A61B 17/0206
9,700,293	B2 *	7/2017	Cryder	A61B 17/025
9,795,370	B2 *	10/2017	O'Connell	A61B 17/0206
9,820,778	B2 *	11/2017	Masson	A61B 17/7077
2002/0123754	A1 *	9/2002	Holmes	A61B 17/7079 606/105
2002/0161368	A1	10/2002	Foley et al.	
2003/0055430	A1 *	3/2003	Kim	A61B 17/0206 606/331
2003/0149341	A1	8/2003	Clifton	
2003/0236447	A1	12/2003	Ritland	
2004/0068269	A1	4/2004	Bonati et al.	
2004/0147928	A1	7/2004	Landry	
2004/0147936	A1	7/2004	Rosenberg et al.	
2004/0215199	A1	10/2004	Zinkel	
2004/0230191	A1	11/2004	Frey	
2005/0010220	A1	1/2005	Casutt	
2005/0021031	A1	1/2005	Foley et al.	
2005/0080320	A1	4/2005	Lee et al.	
2005/0090824	A1	4/2005	Schluzas et al.	
2005/0131422	A1	6/2005	Anderson et al.	
2005/0148826	A1	7/2005	Paolitto et al.	
2005/0149053	A1	7/2005	Varieur	
2005/0165408	A1	7/2005	Puno et al.	
2005/0171542	A1	8/2005	Biedermann	
2005/0192486	A1	9/2005	Harnel	
2005/0192570	A1	9/2005	Jackson	
2005/0203533	A1 *	9/2005	Ferguson	A61B 17/025 606/90
2005/0234304	A1	10/2005	Dewey	
2005/0240081	A1	10/2005	Eliachar	
2005/0245928	A1	11/2005	Colleran et al.	
2005/0277812	A1	12/2005	Myles	
2005/0277928	A1	12/2005	Boshert	
2006/0025771	A1	2/2006	Jackson	
2006/0036244	A1	2/2006	Spitler	
2006/0075856	A1	4/2006	Tilton	
2006/0084844	A1 *	4/2006	Nehls	A61B 17/0206 600/227
2006/0100622	A1	5/2006	Jackson	
2006/0111712	A1	5/2006	Jackson	
2006/0111715	A1	5/2006	Jackson	
2006/0142761	A1	6/2006	Landry	
2006/0149232	A1	7/2006	Sasing	
2006/0149240	A1	7/2006	Jackson	
2006/0183978	A1	8/2006	Howard	
2006/0189848	A1	8/2006	Penenberg	
2006/0200133	A1	9/2006	Jackson	
2006/0206009	A1	9/2006	Von Wald	
2006/0241603	A1	10/2006	Jackson	
2006/0241618	A1	10/2006	Gasser	
2006/0247637	A1	11/2006	Colleran	
2006/0247658	A1	11/2006	Pond	
2006/0271047	A1	11/2006	Jackson	
2006/0271050	A1	11/2006	Piza Vallespir	
2006/0276789	A1	12/2006	Jackson	
2006/0276792	A1	12/2006	Ensign	
2006/0278050	A1	12/2006	Hsiao	
2006/0287674	A1	12/2006	Ginn et al.	
2007/0016200	A1	1/2007	Jackson	
2007/0032162	A1	2/2007	Jackson	
2007/0038033	A1	2/2007	Jones	
2007/0049931	A1	3/2007	Justis	
2007/0049933	A1	3/2007	Ahn	
2007/0055109	A1 *	3/2007	Bass	A61B 17/02 600/234
2007/0055240	A1	3/2007	Matthis	
2007/0055241	A1	3/2007	Matthis	
2007/0055244	A1	3/2007	Jackson	
2007/0073111	A1	3/2007	Bass	
2007/0073112	A1	3/2007	Holmes	
2007/0083086	A1	4/2007	LeVahn et al.	
2007/0088357	A1	4/2007	Johnson	
2007/0090238	A1	4/2007	Justis	
2007/0093818	A1	4/2007	Biedermann	
2007/0093828	A1	4/2007	Abdou	
2007/0100212	A1	5/2007	Pimenta et al.	
2007/0106123	A1	5/2007	Gorek et al.	
2007/0123862	A1	5/2007	Warnick	
2007/0123870	A1	5/2007	Jeon et al.	
2007/0129608	A1	6/2007	Sandhu	
2007/0135817	A1	6/2007	Ensign	
2007/0156024	A1	7/2007	Frasier	
2007/0167949	A1	7/2007	Altarac et al.	
2007/0173819	A1	7/2007	Sandlin	
2007/0179343	A1	8/2007	Shelokov	
2007/0191955	A1	8/2007	Zucherman et al.	
2007/0198062	A1	8/2007	Miles	
2007/0208227	A1	9/2007	Smith et al.	
2007/0208228	A1	9/2007	Pavento et al.	
2007/0225568	A1	9/2007	Colleran	
2007/0233079	A1	10/2007	Fallin et al.	
2007/0233097	A1	10/2007	Anderson et al.	
2007/0238932	A1	10/2007	Jones et al.	
2007/0270842	A1	11/2007	Bankoski et al.	
2008/0021285	A1	1/2008	Drzyzga	
2008/0045957	A1	2/2008	Landry	
2008/0077139	A1	2/2008	Landry et al.	
2008/0077136	A1	3/2008	Triplett	
2008/0077138	A1	3/2008	Cohen	
2008/0154277	A1	3/2008	Machalk et al.	
2008/0114208	A1	5/2008	Hutton	
2008/0146881	A1	6/2008	Alimi	
2008/0154281	A1	6/2008	Schaffran et al.	
2008/0183044	A1	7/2008	Colleran	
2008/0183214	A1	7/2008	Copp et al.	
2008/0188718	A1	8/2008	Spitler	
2008/0249372	A1	10/2008	Reglos	
2008/0262318	A1	10/2008	Gorek	
2009/0012370	A1	1/2009	Gutierrez	
2009/0018399	A1	1/2009	Martinelli et al.	
2009/0036746	A1 *	2/2009	Blackwell	A61B 17/0206 600/219
2009/0076333	A1	3/2009	Bjork	
2009/0076516	A1	3/2009	Lowry	
2009/0105547	A1	4/2009	Vayser	
2009/0124860	A1	5/2009	Miles	
2009/0124861	A1	5/2009	Fetzer	
2009/0222046	A1	9/2009	Gorek	
2009/0227845	A1	9/2009	Lo	
2009/0270916	A1	10/2009	Ramsay et al.	
2010/0030224	A1	2/2010	Winslow et al.	
2010/0081885	A1	4/2010	Wing	
2010/0114182	A1	5/2010	Wilcox et al.	
2010/0137915	A1	6/2010	Anderson et al.	
2010/0217089	A1	8/2010	Farley	
2010/0249856	A1	9/2010	Iott et al.	
2010/0262198	A1	10/2010	Braunschweiler et al.	
2010/0298647	A1	11/2010	Black	
2010/0298648	A1	11/2010	Gray	
2010/0312068	A1	12/2010	Dalton	
2010/0331849	A1 *	12/2010	Riesinger	A61B 17/7077 606/90
2010/0331901	A1	12/2010	Iott et al.	
2011/0004067	A1	1/2011	Marchek	
2011/0022088	A1	1/2011	Forton et al.	
2011/0034780	A1	2/2011	Loftus et al.	
2011/0137130	A1	6/2011	Thalgott	
2011/0201897	A1	8/2011	Bertagnoli	
2011/0208008	A1	8/2011	Michaeli	
2011/0224497	A1	9/2011	Weiman	
2011/0245836	A1	10/2011	Hamada	
2011/0257487	A1	10/2011	Thalgott	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2011/0301423	A1	12/2011	Koros	
2012/0065693	A1	3/2012	Lim et al.	
2012/0271364	A1	10/2012	Sharifi-Mehr et al.	
2014/0066718	A1*	3/2014	Fiechter	A61B 17/0206 600/214
2014/0107656	A1*	4/2014	Masson	A61B 17/7077 606/90
2015/0313585	A1*	11/2015	Abidin	A61B 17/0206 600/213
2016/0106408	A1*	4/2016	Ponmudi	A61B 17/025 606/90
2016/0331361	A1*	11/2016	Masson	A61B 17/7077
2017/0035406	A1*	2/2017	Abidin	A61B 17/0206
2017/0086812	A1*	3/2017	Mast	A61B 17/7079
2017/0143323	A1*	5/2017	Cryder	A61B 17/025
2017/0189080	A1*	7/2017	Reitblat	A61B 17/7077
2017/0196597	A1*	7/2017	Corbin	A61B 17/7049
2017/0265850	A1*	9/2017	Cryder	A61B 17/025
2017/0273677	A1*	9/2017	Gorek	A61B 17/7082

FOREIGN PATENT DOCUMENTS

FR	2788958	8/2000
JP	10277043	10/1998
WO	WO1998038921	9/1998
WO	WO2001006940	2/2001
WO	WO20080823836	7/2008
WO	WO2008131084	10/2008
WO	WO2010057980	5/2010

OTHER PUBLICATIONS

Dhall, et al. Clinical and Radiographic comparison of Mini-open Transforaminal Lumbar Interbody Fusion with Open Transforaminal Lumbar Interbody Fusion in 42 Patients with Lo.

Foley, et al. "Minimally Invasive Lumbar Fusion" Spine, 2003, 28:S26-S35.

Holly, et al. "Minimally INvasive Transformainal Lumbar Interbody Fusion: indications, technique, and Complications" Neurosurg Focus, 2006 20:E6, 5 pages.

Mummaneni and Rodts, "The mini-open transforminal Lumbar Interbody Fusion" Neurosurgery, 2005, S7:256-261.

Ozgur, et al. "Minimally Disruptive Decompression and Transforaminal Lumbar Interbody Fusion" The Spine Journal, 2006, 6:27-33.

Ozgur, et al. "Minimally-invasive Technique for Transforaminal Lumbar Interbody Fusion (TLIF)," Eur Spine J., 2005, 14:887-894.

Schwender et al. "Minimally invasive transforaminal lumbar interbody fusion (TLIF): technical feasibility and initial results," J Spinal Disord Tech., 2005, 18(1):S1-S6.

Authorized Officer Blaine R. Copenheaver, International Search Report and Written Opinion from PCT/US2010/002951, dated Mar. 23, 2011, 19 pages.

* cited by examiner

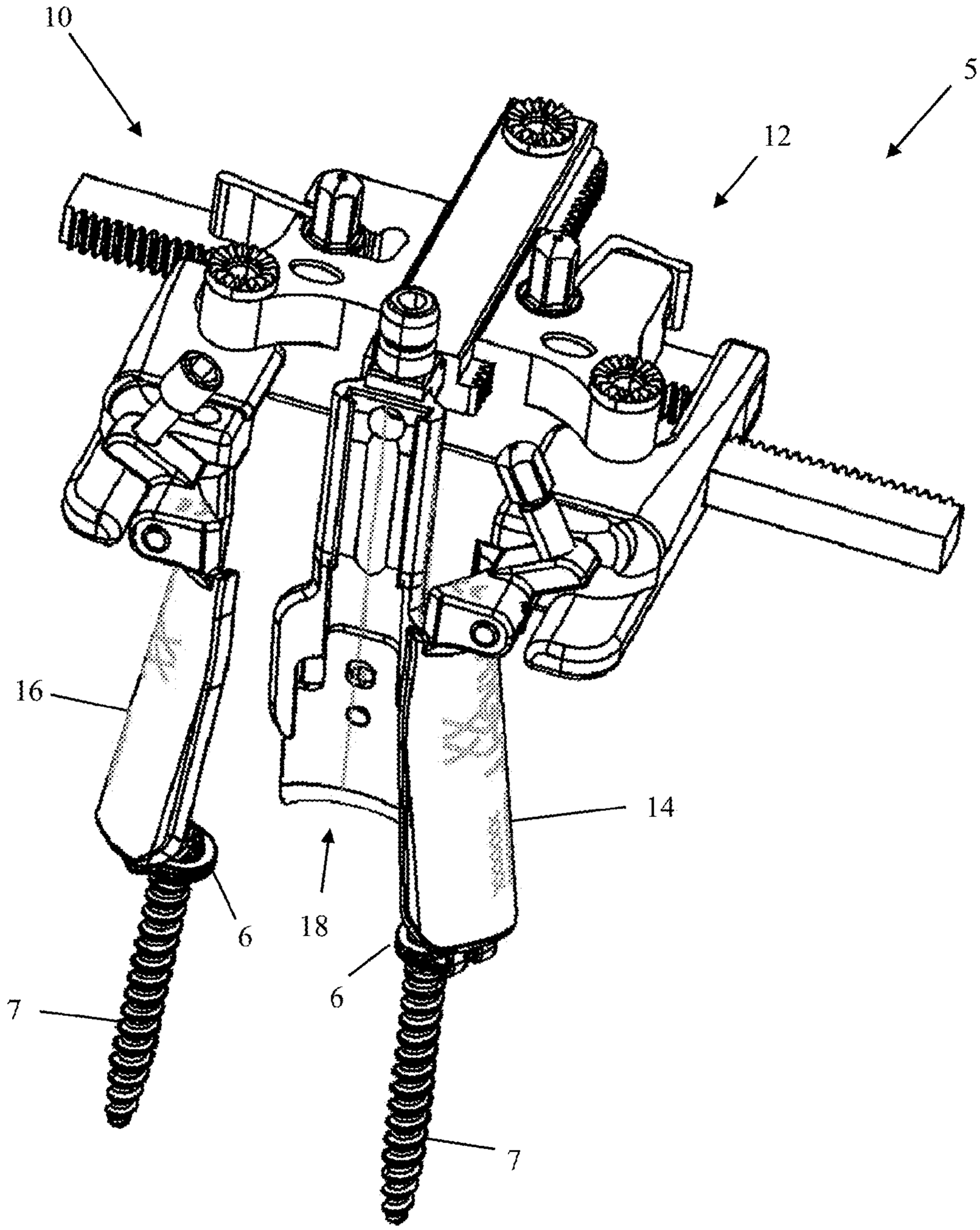


Fig. 1

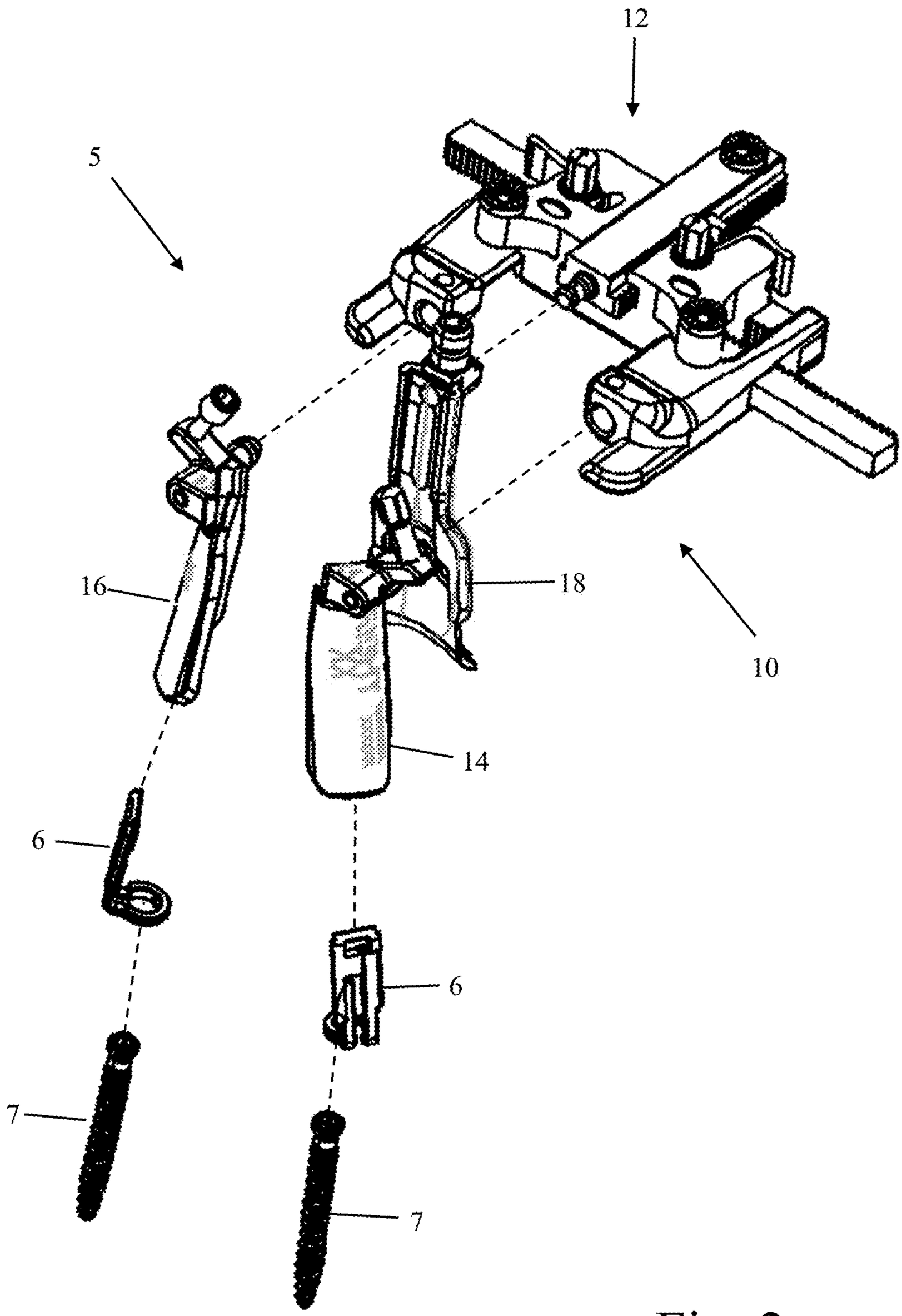


Fig. 2

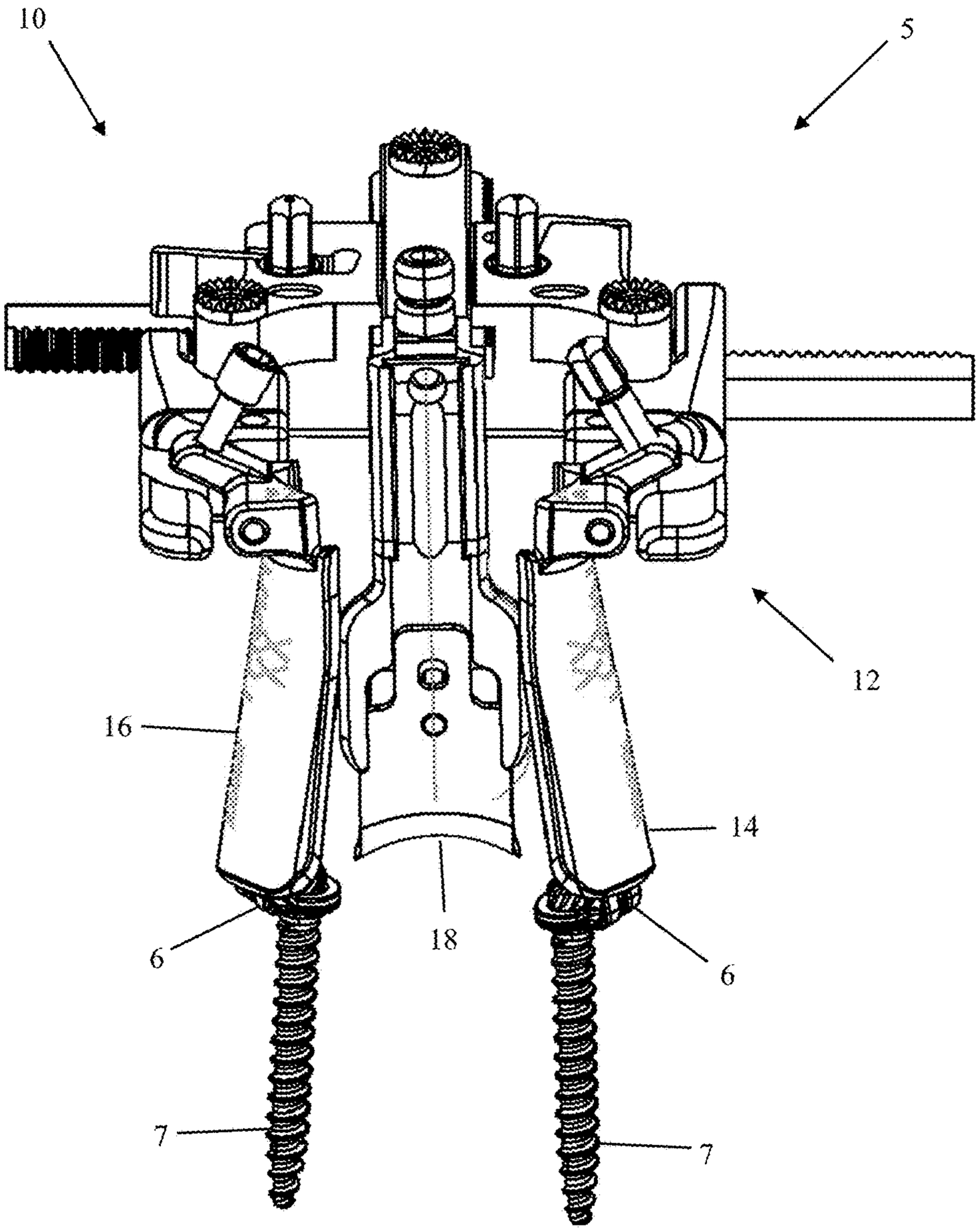


Fig. 3

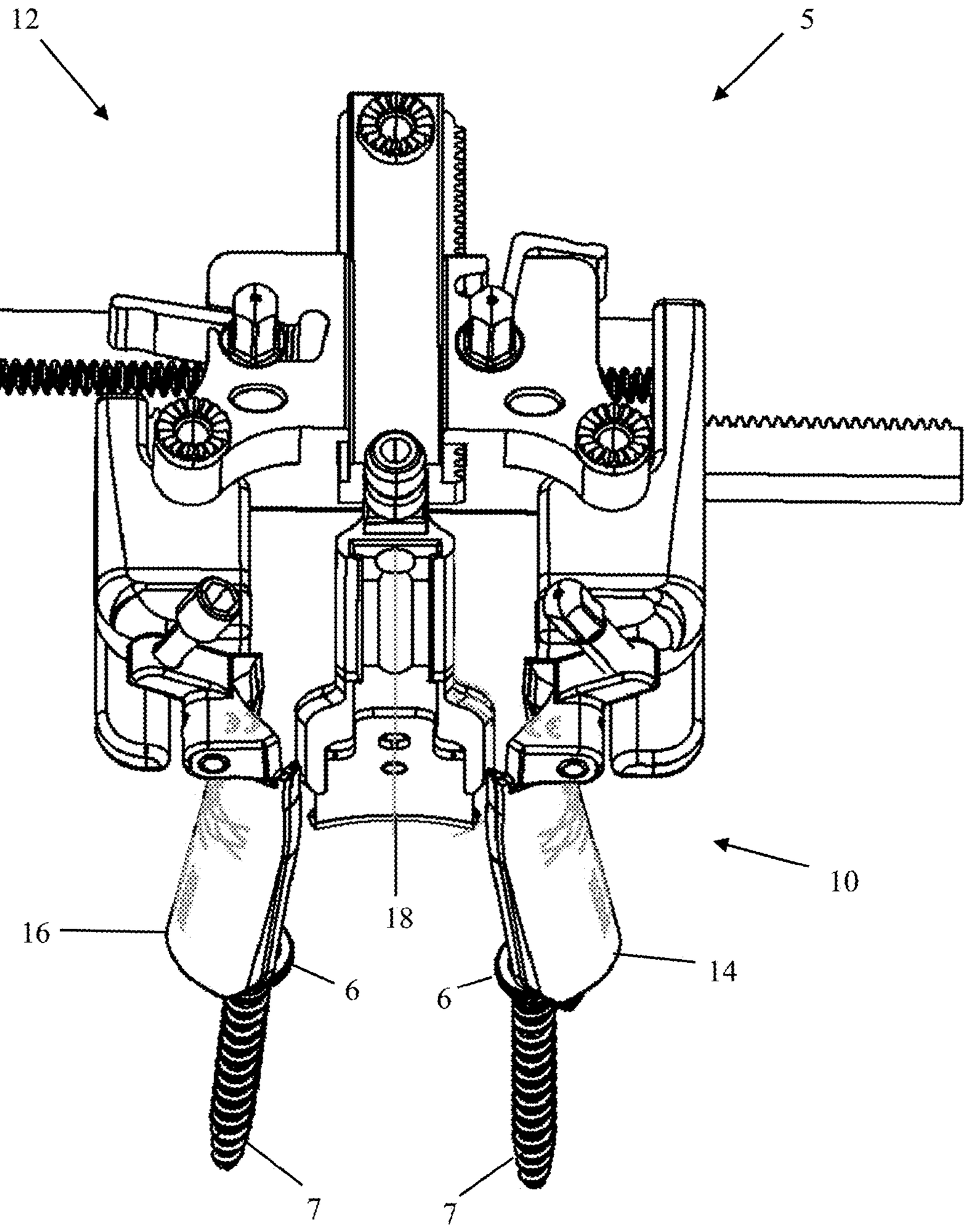


Fig. 4

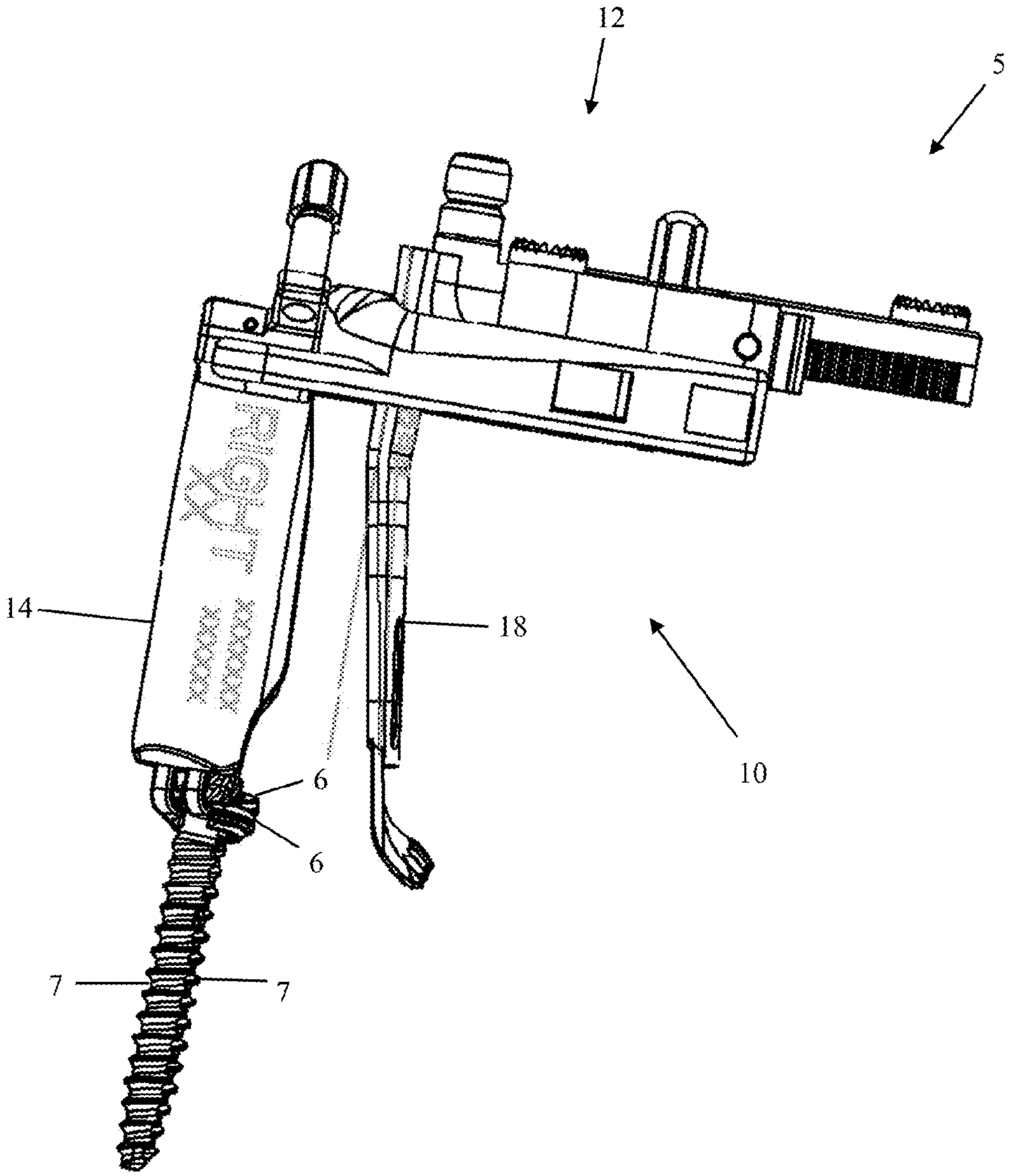


Fig. 5

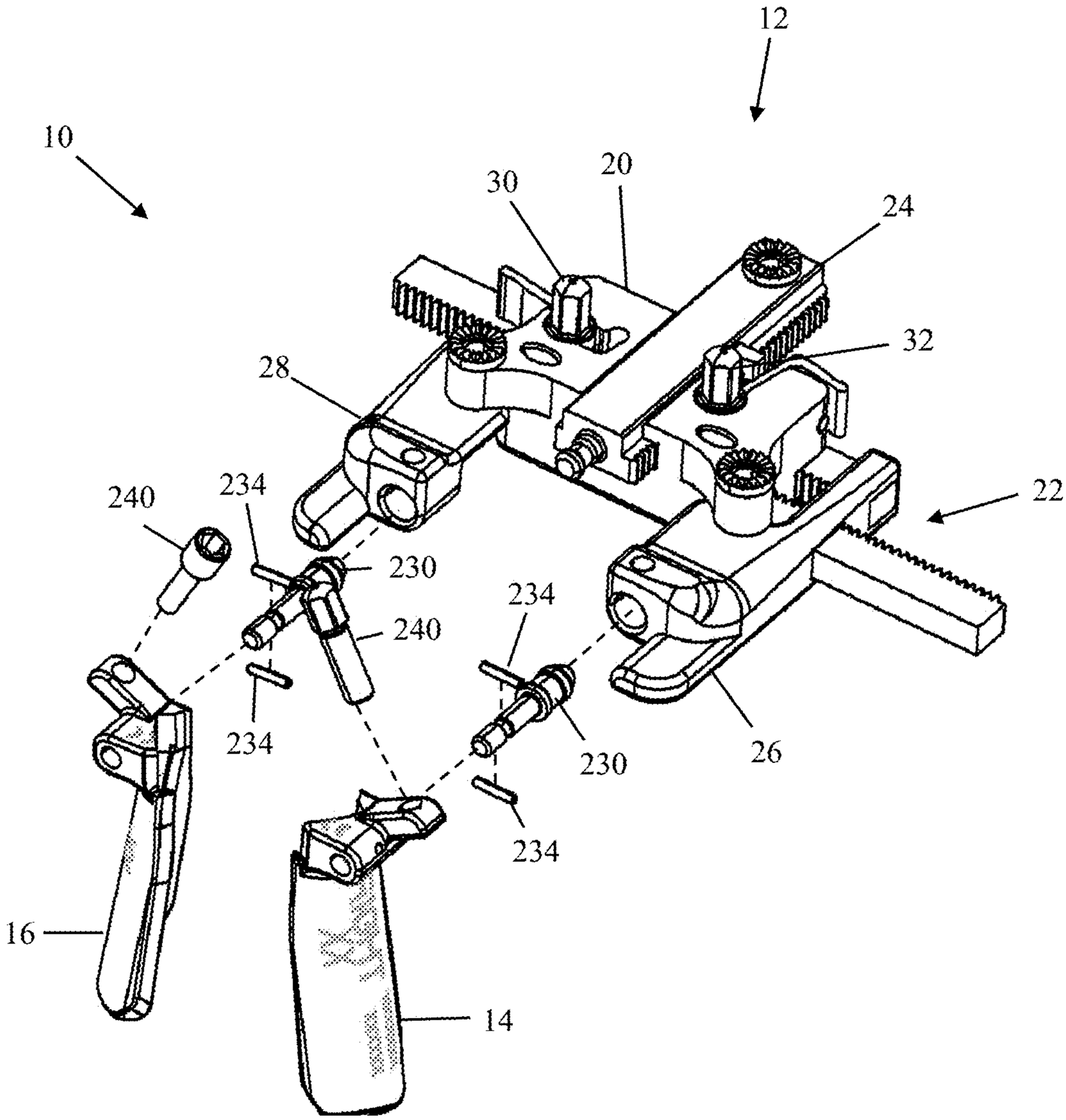


Fig. 6

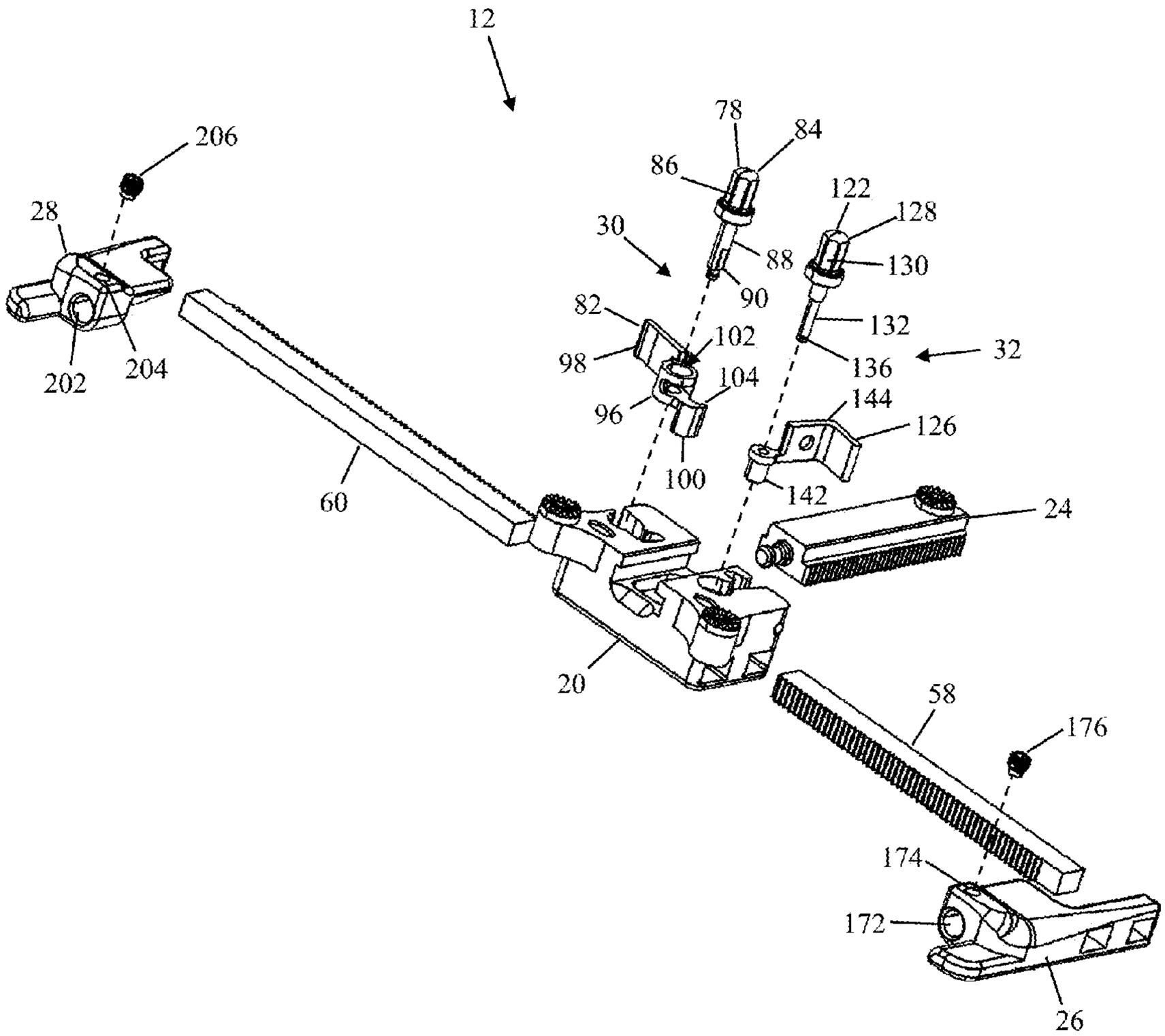

12
78
84
86
206
28
30
122
128
88
130
90
82
132
102
98
32
136
104
96
144
126
100
142
60
24
20
58
176
174
172
26

Fig. 7

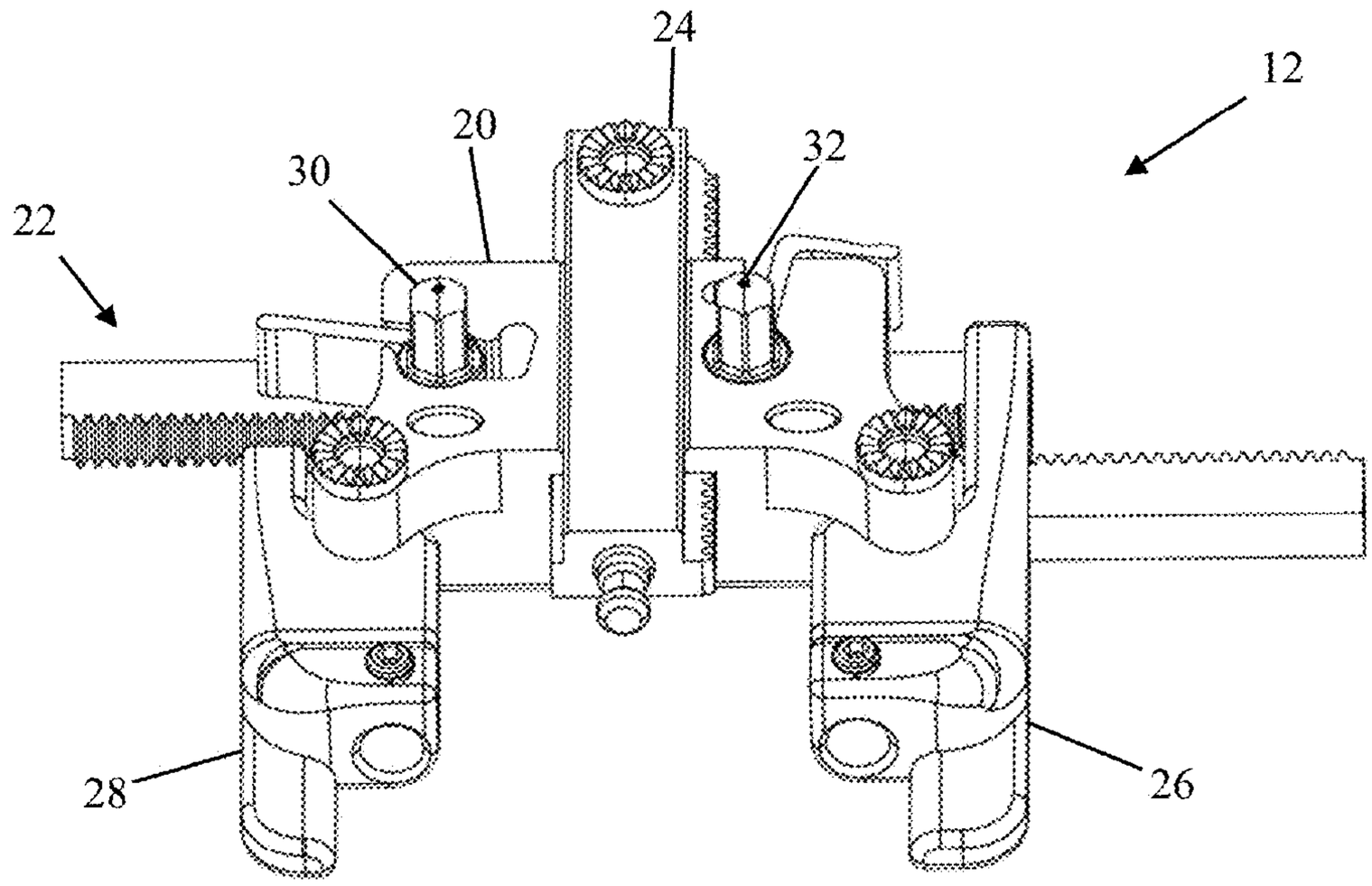

24
12
20
32
30
22
28
26

Fig. 8

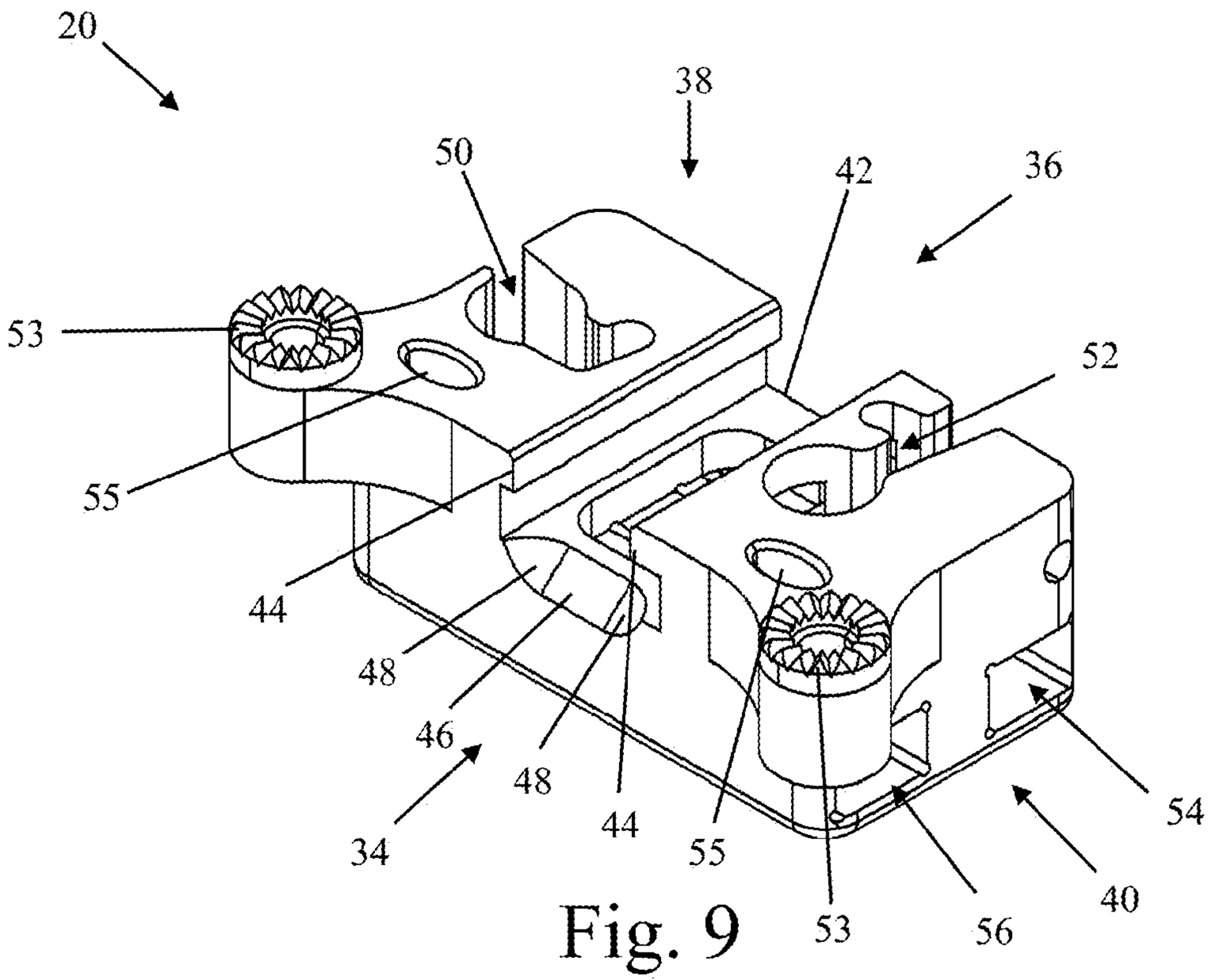

20
38
50
42
36
53
52
55
44
48
46
48
44
55
34
53
56
54
40

Fig. 9

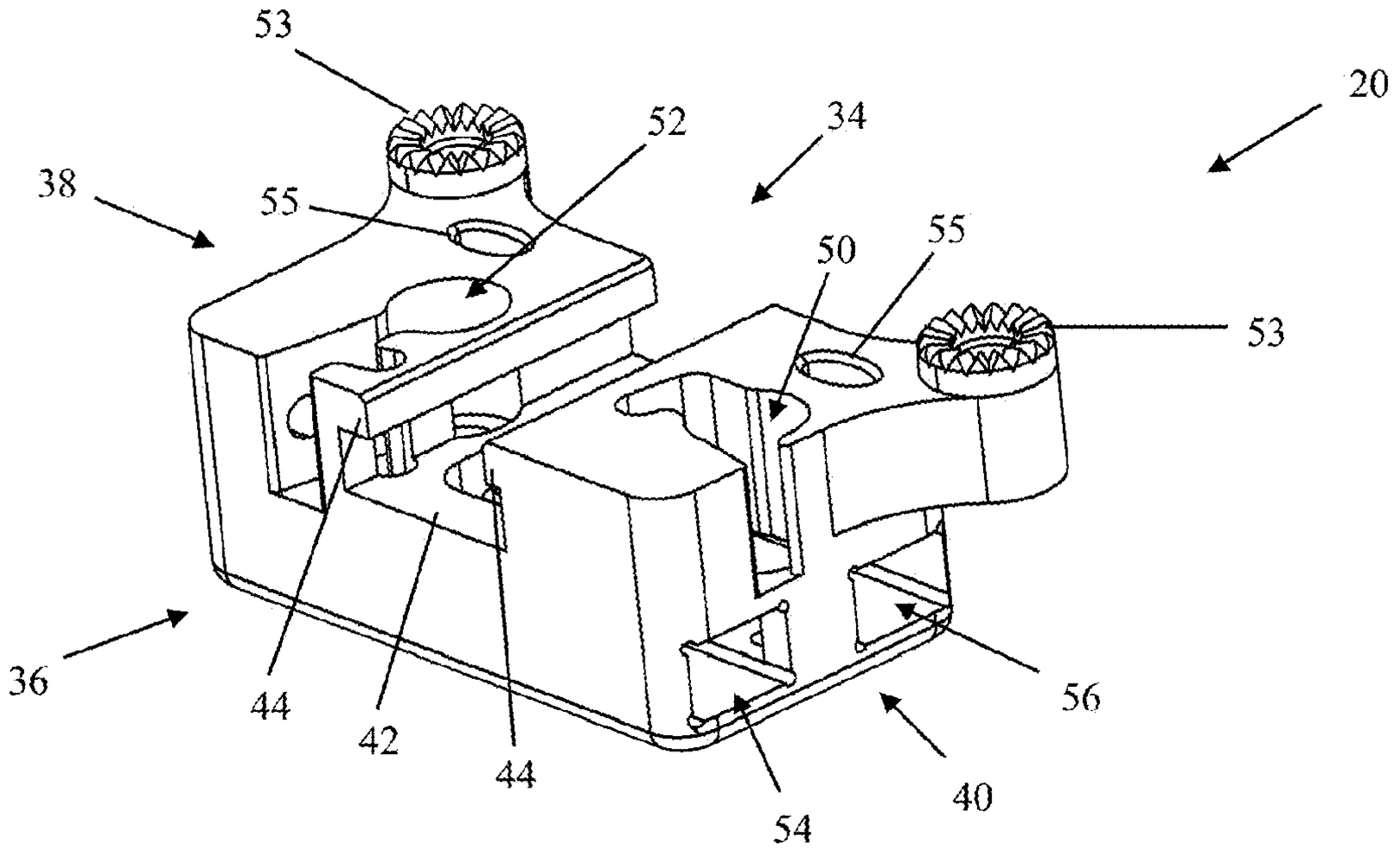

53
52
34
20
38
55
50
55
53
36
44
42
44
56
54
40

Fig. 10

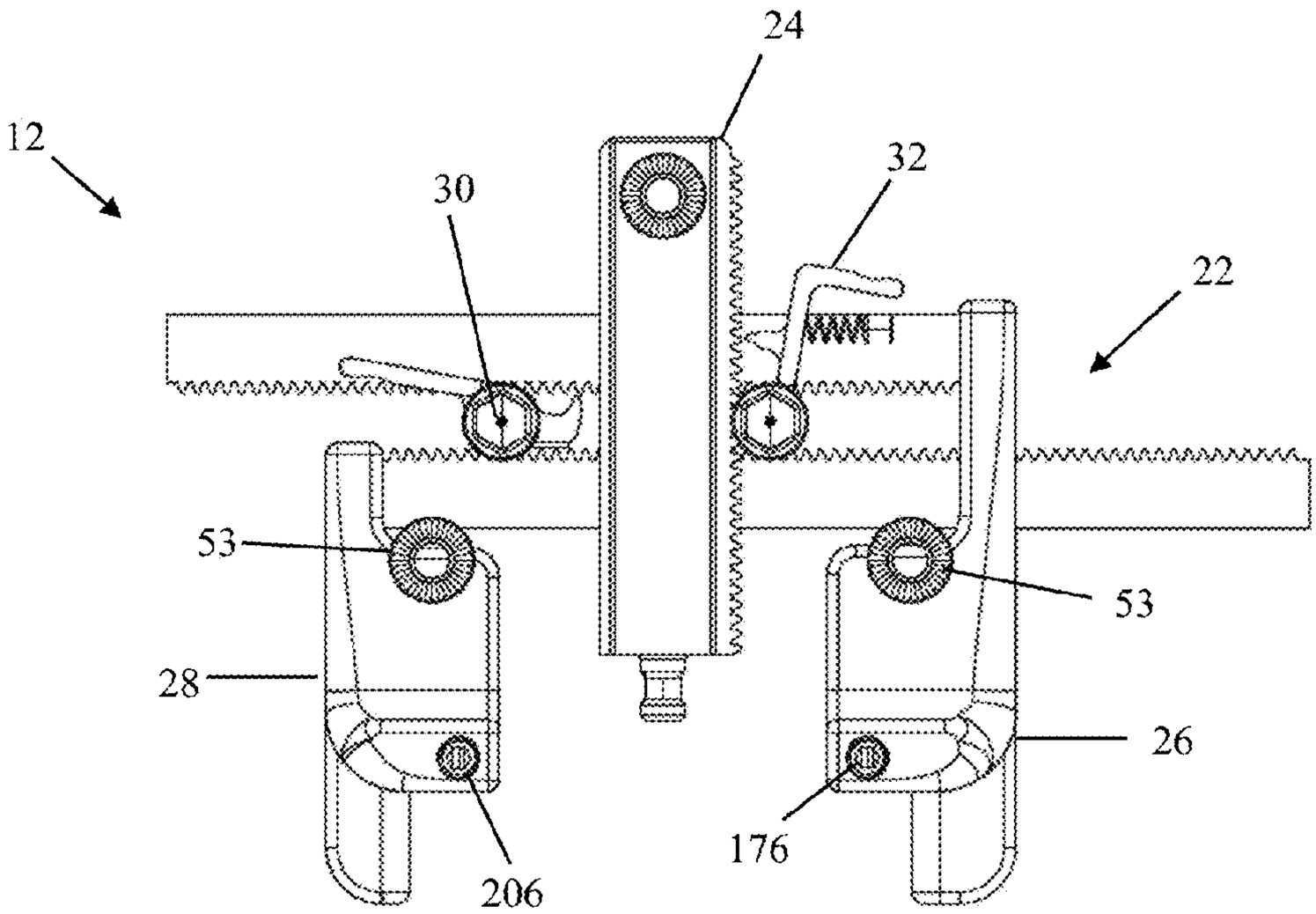

24
12
30
32
22
53
53
28
26
206
176

Fig. 11

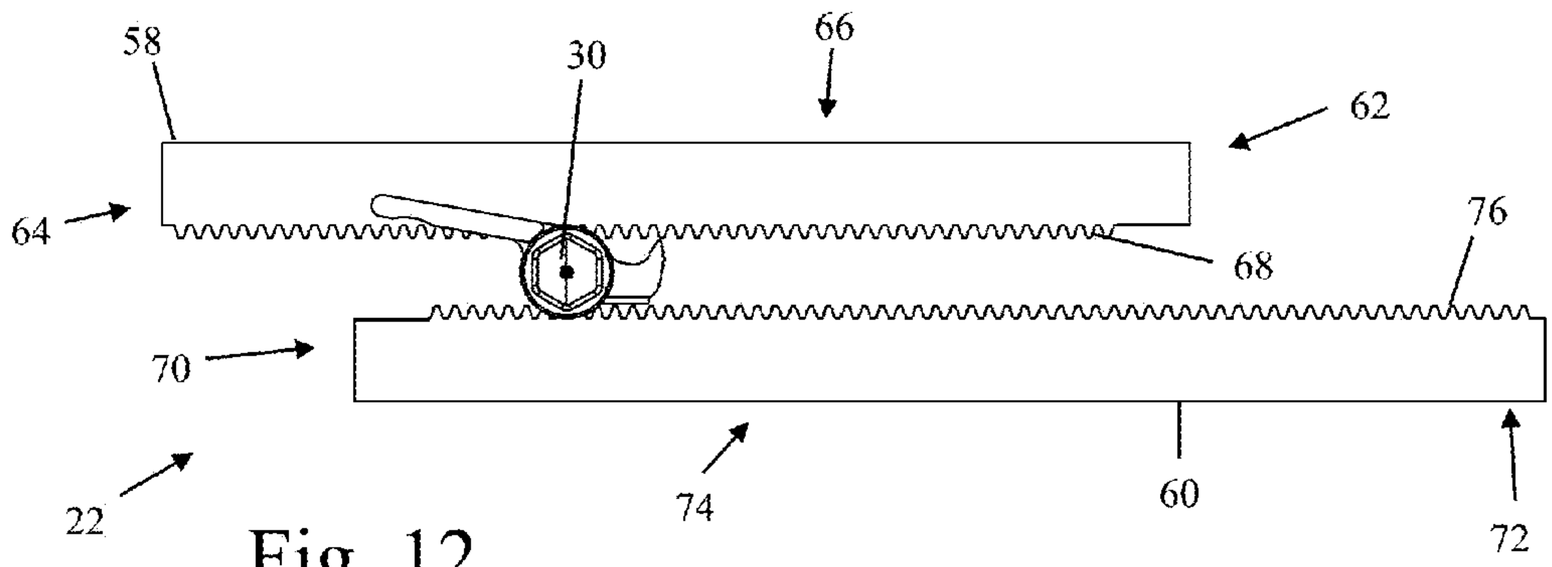


Fig. 12

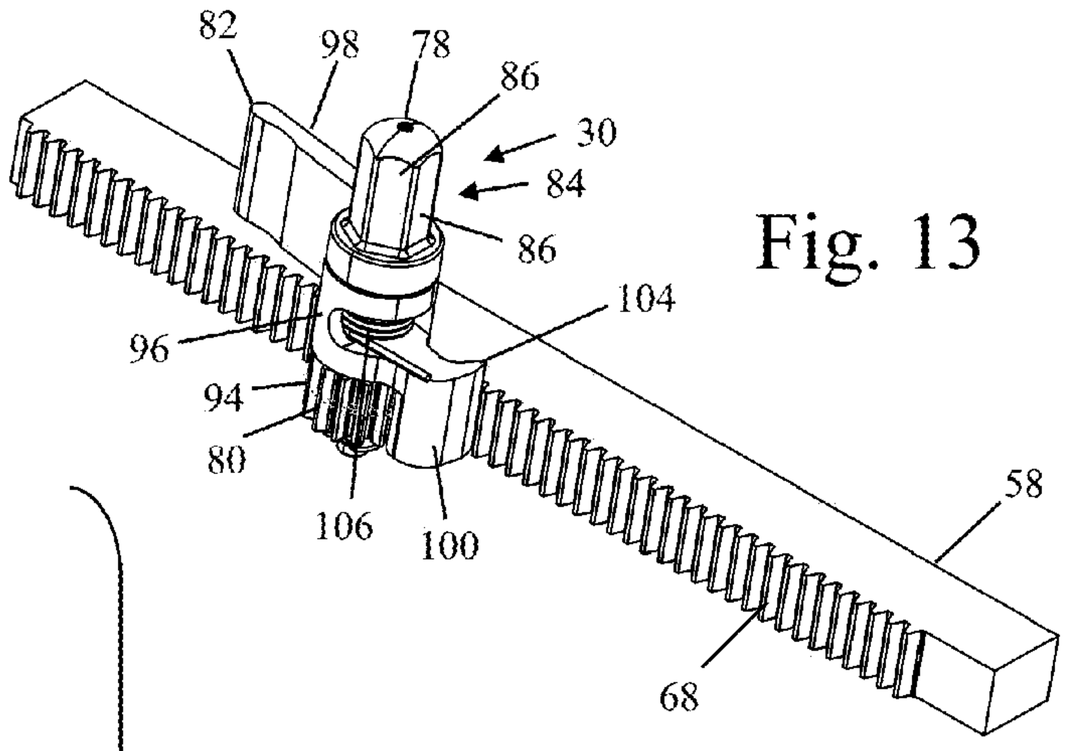


Fig. 13

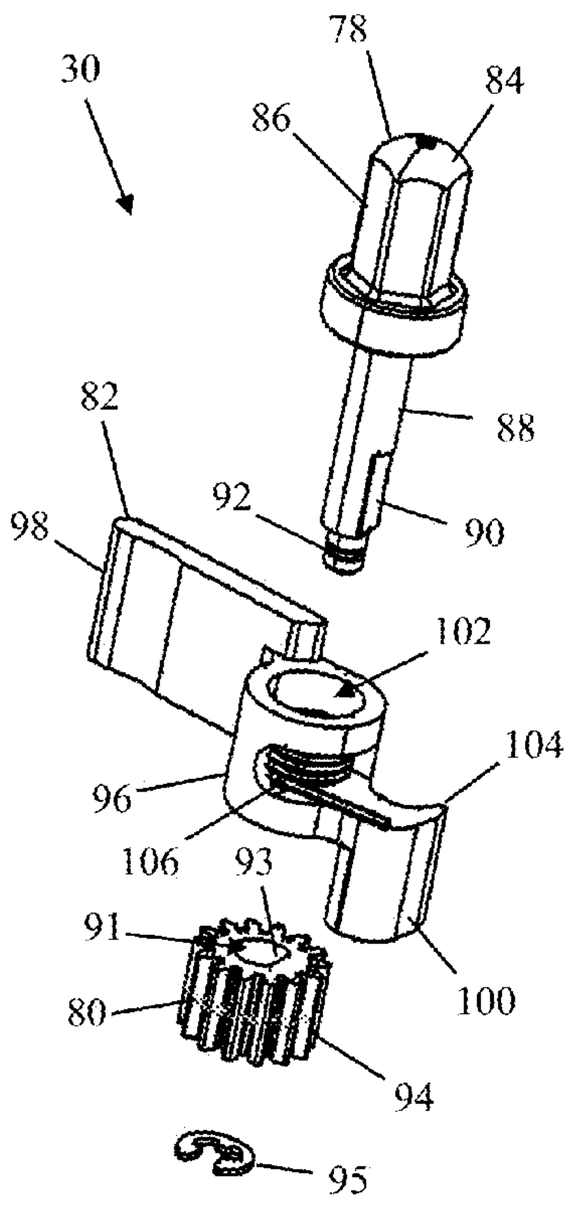


Fig. 14

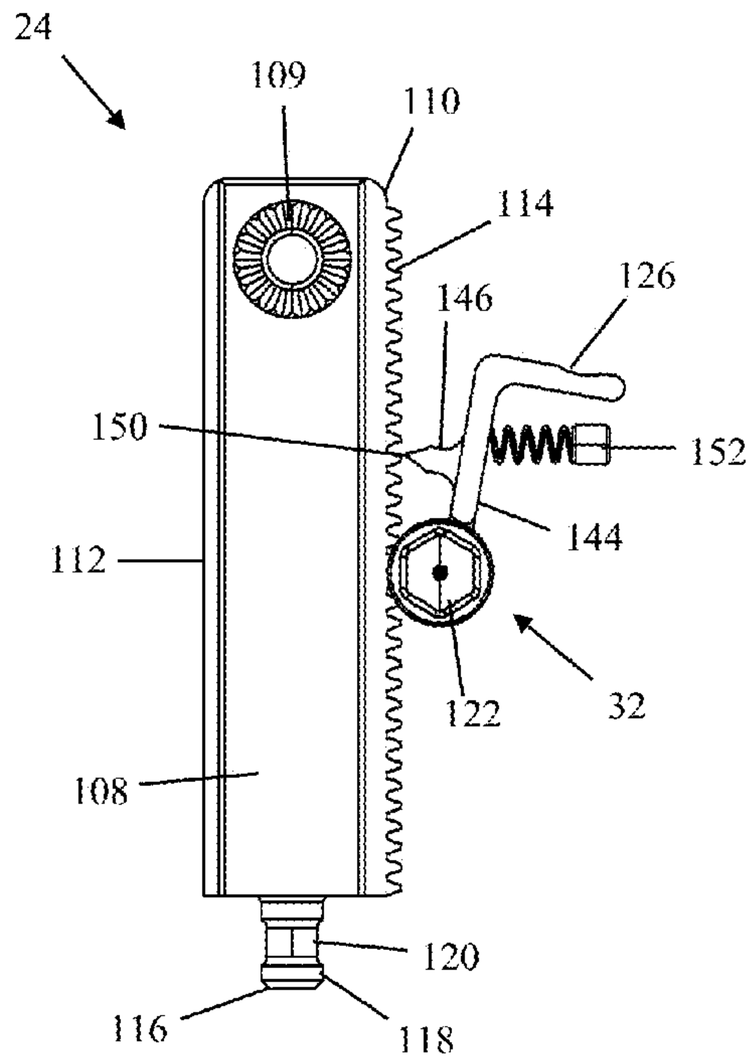


Fig. 15

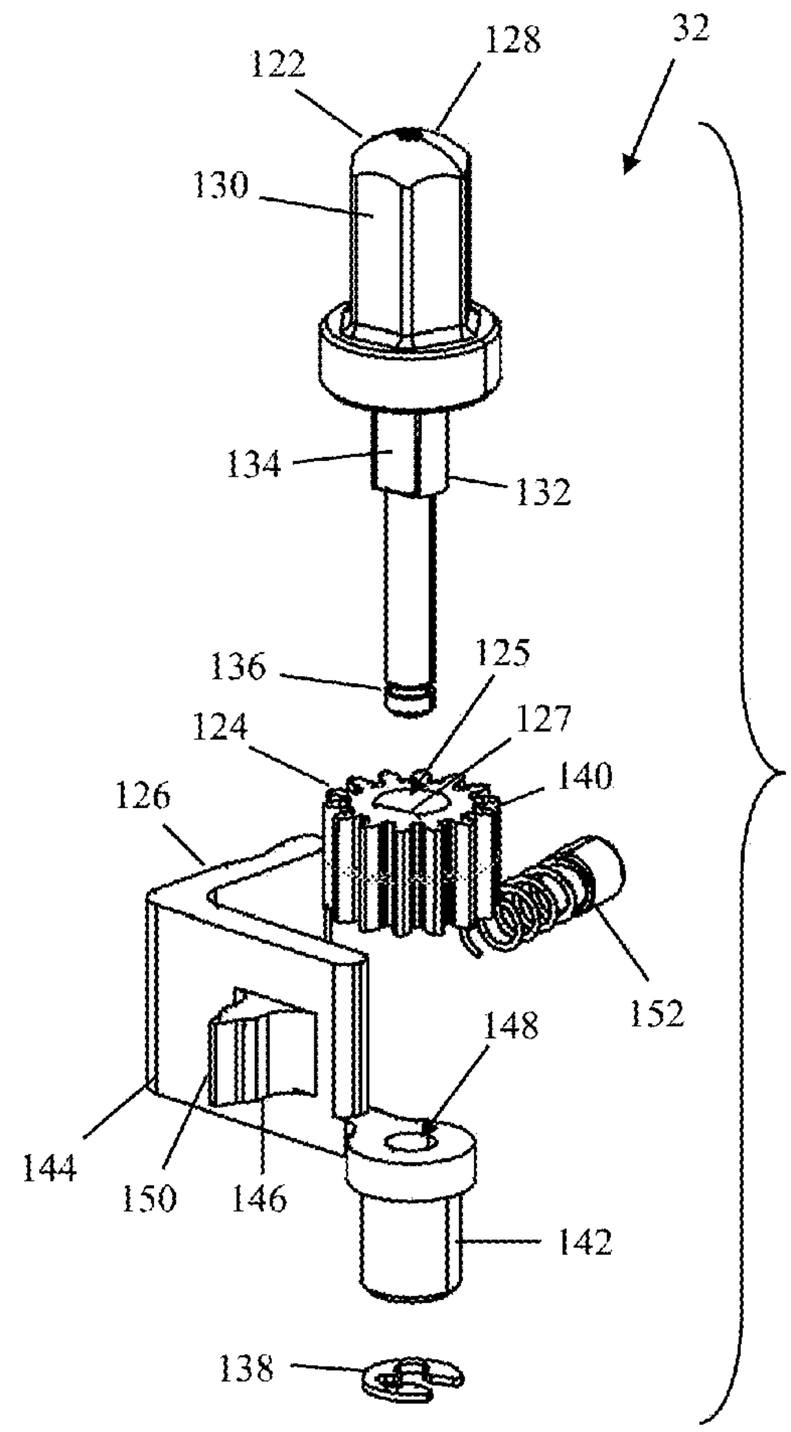


Fig. 17

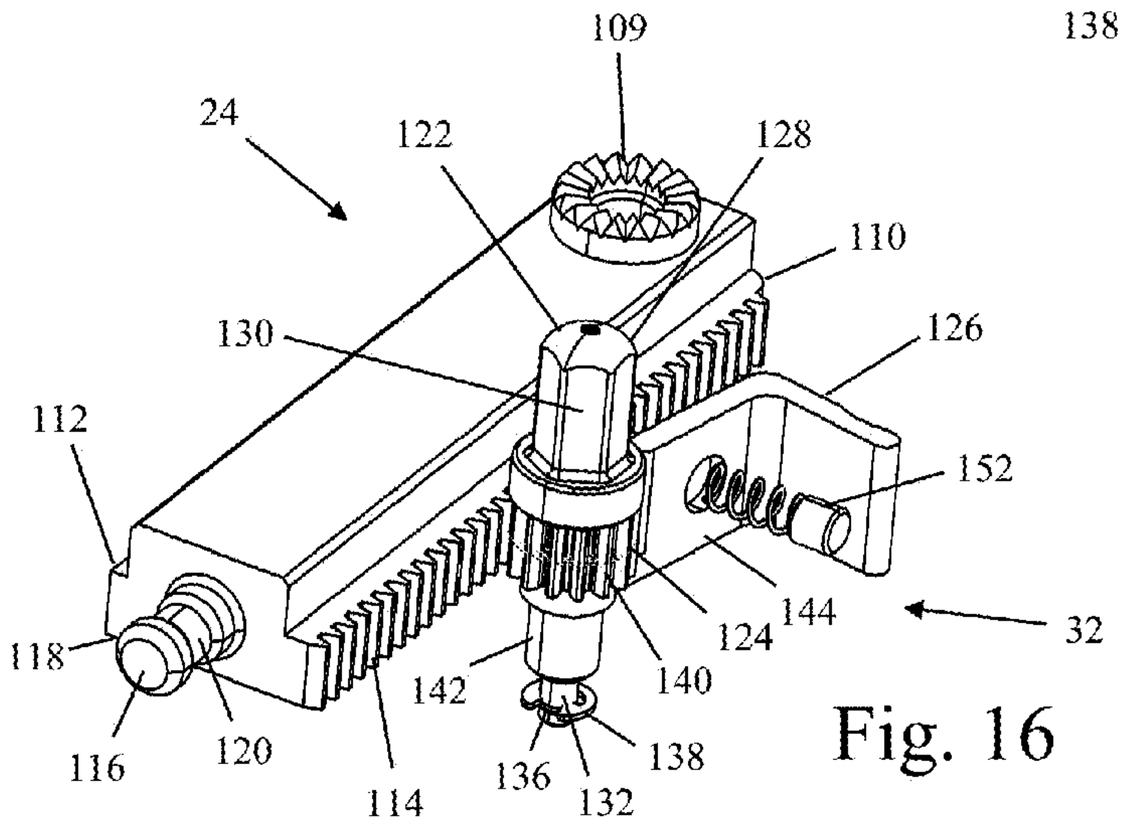


Fig. 16

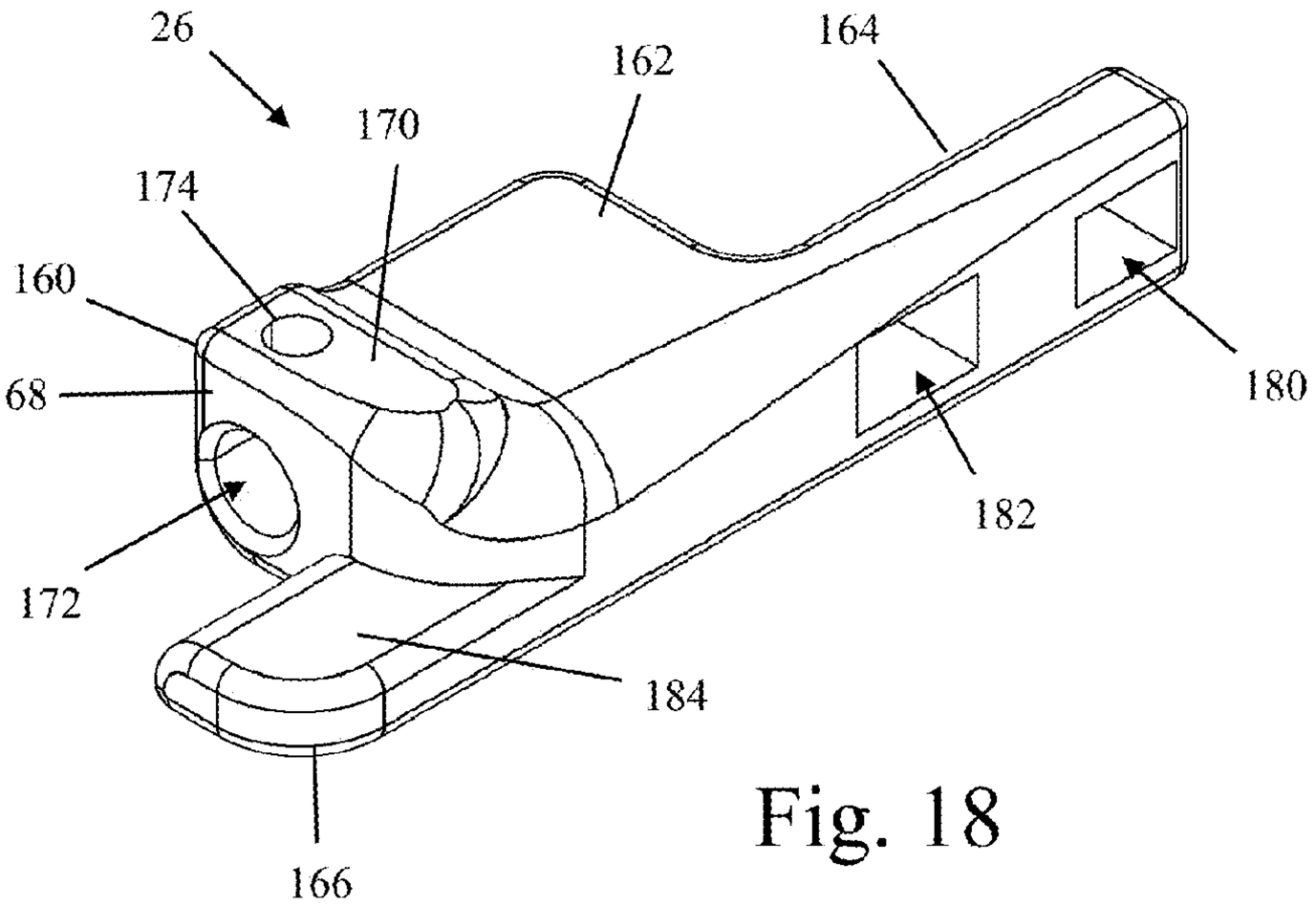

26
162
164
170
174
160
168
180
182
172
184
166

Fig. 18

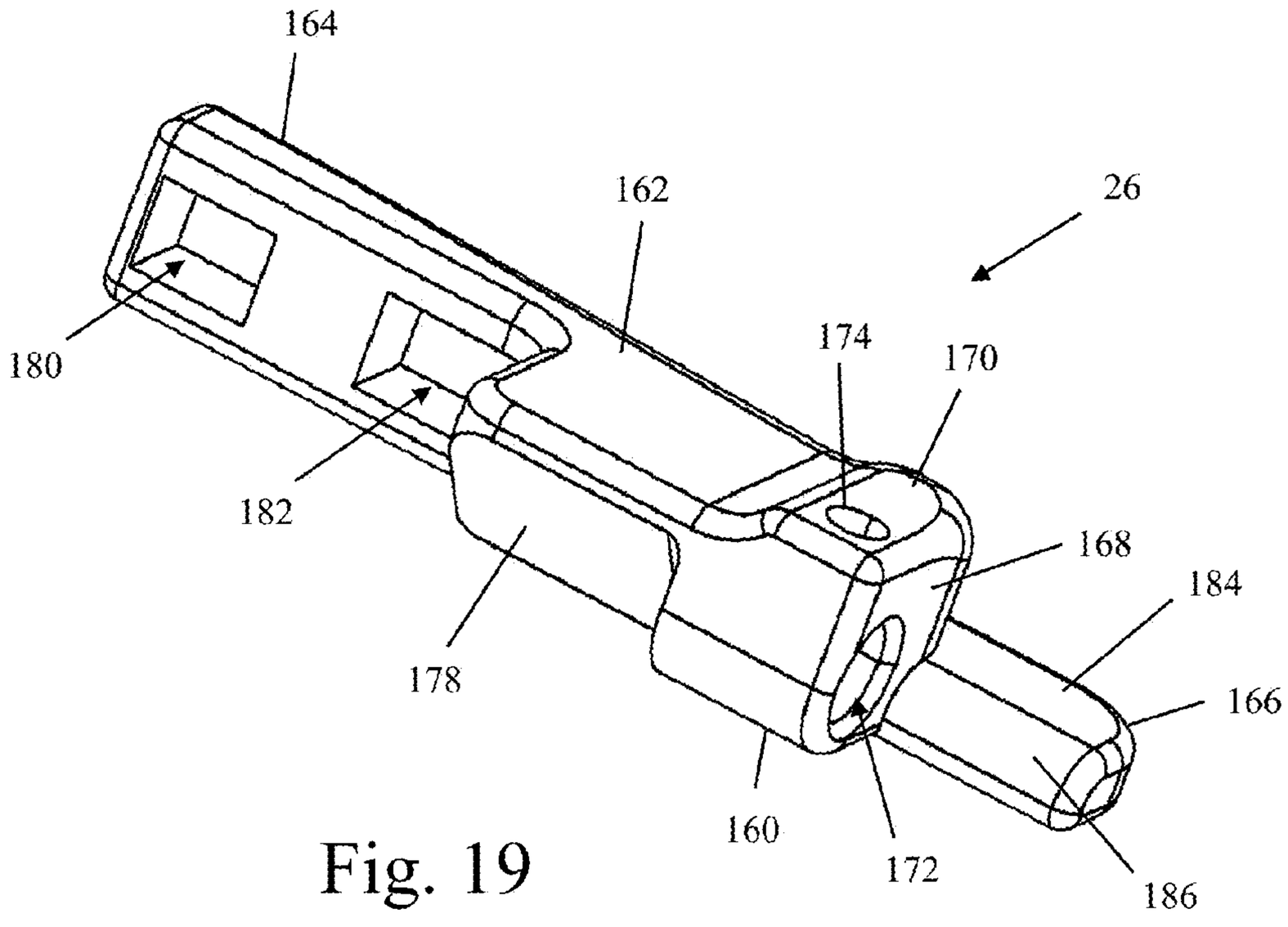

164
162
26
180
174
170
182
168
184
178
166
160
172
186

Fig. 19

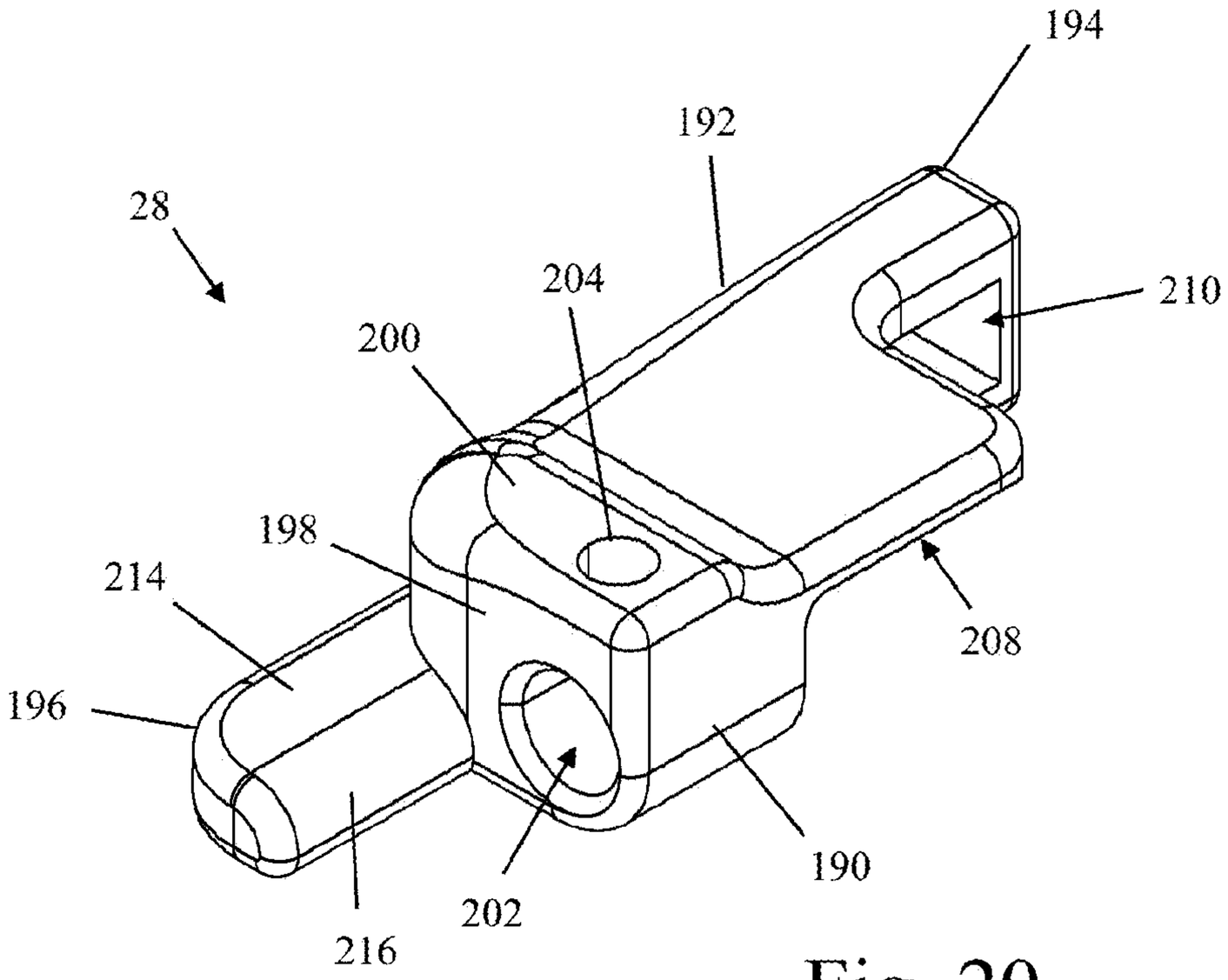

194
192
28
204
210
200
198
214
208
196
190
202
216

Fig. 20

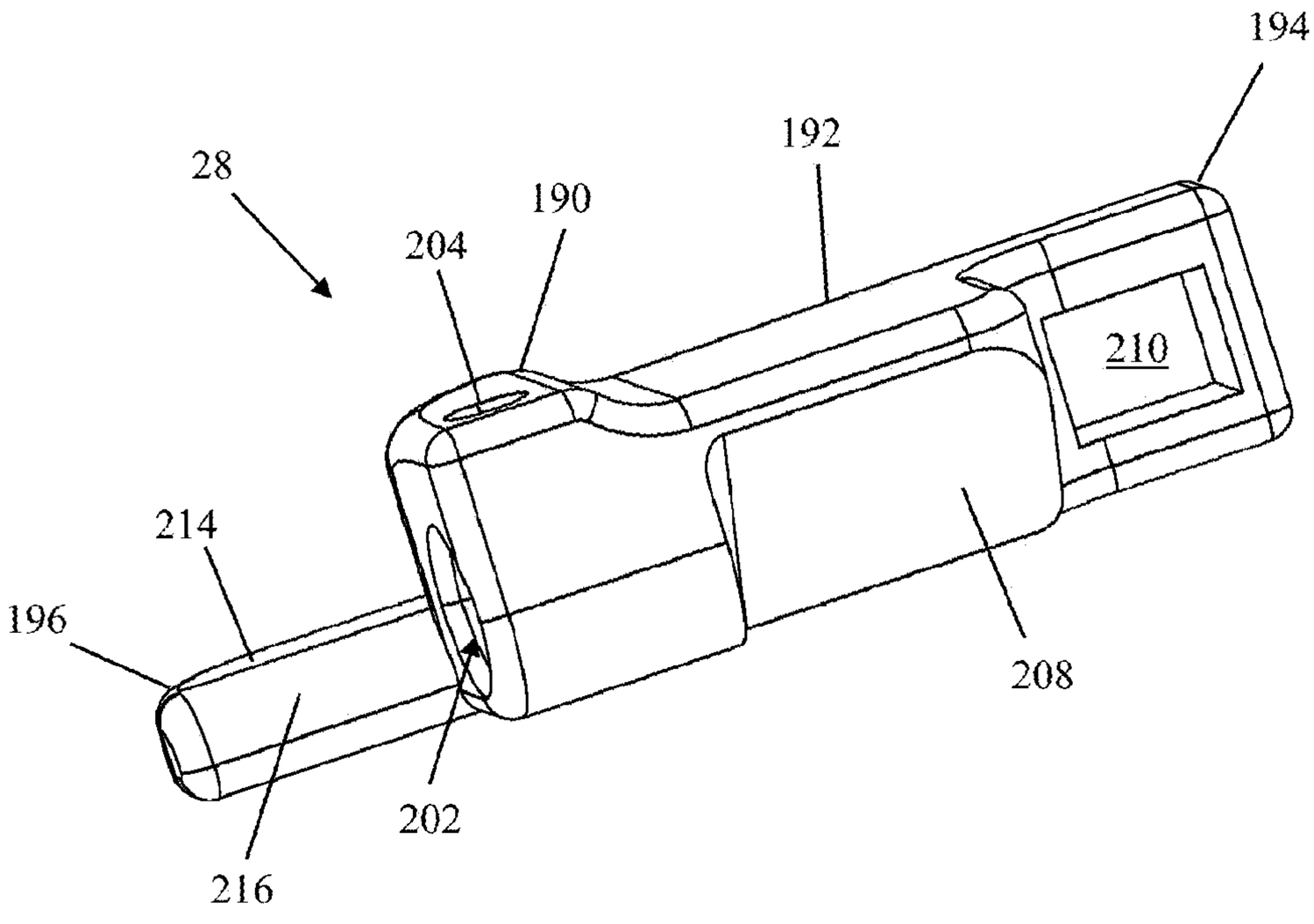

194
192
28
190
204
210
214
196
208
202
216

Fig. 21

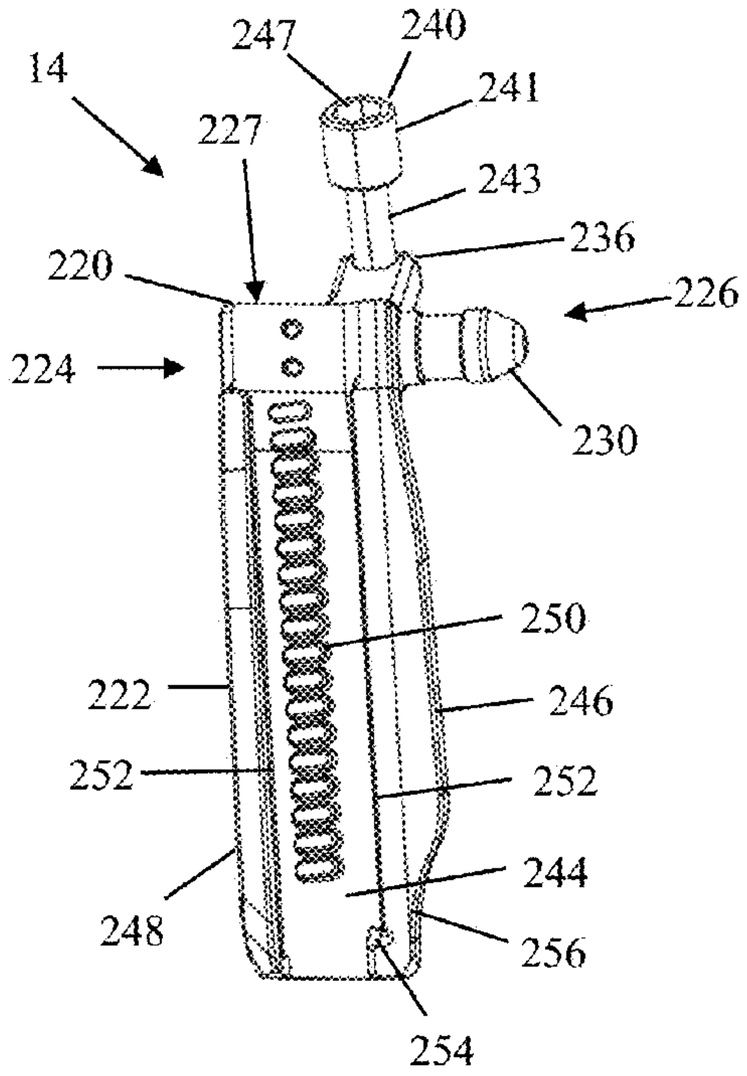


Fig. 22

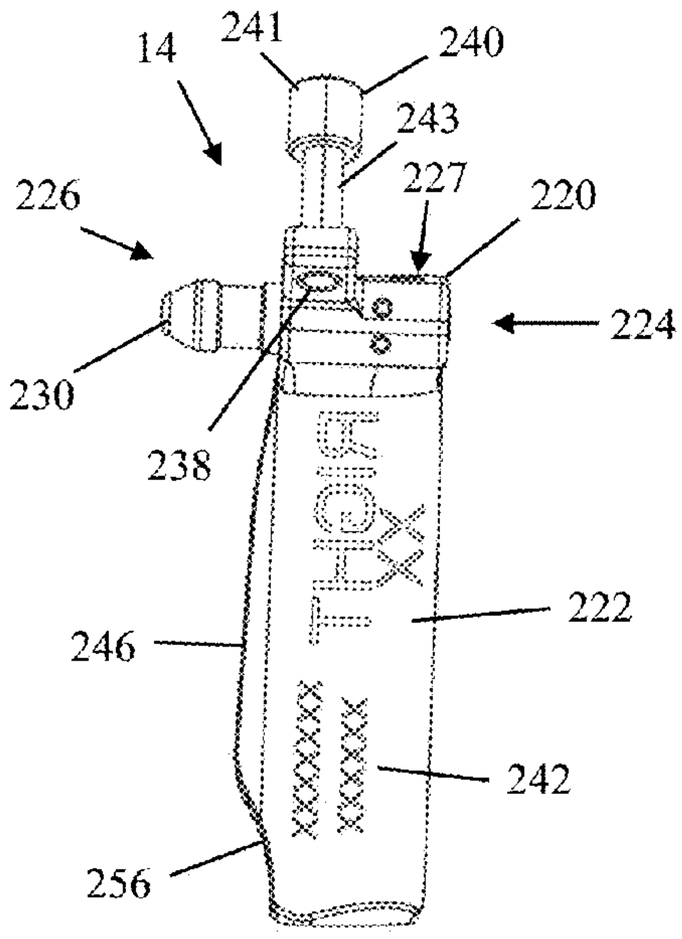


Fig. 23

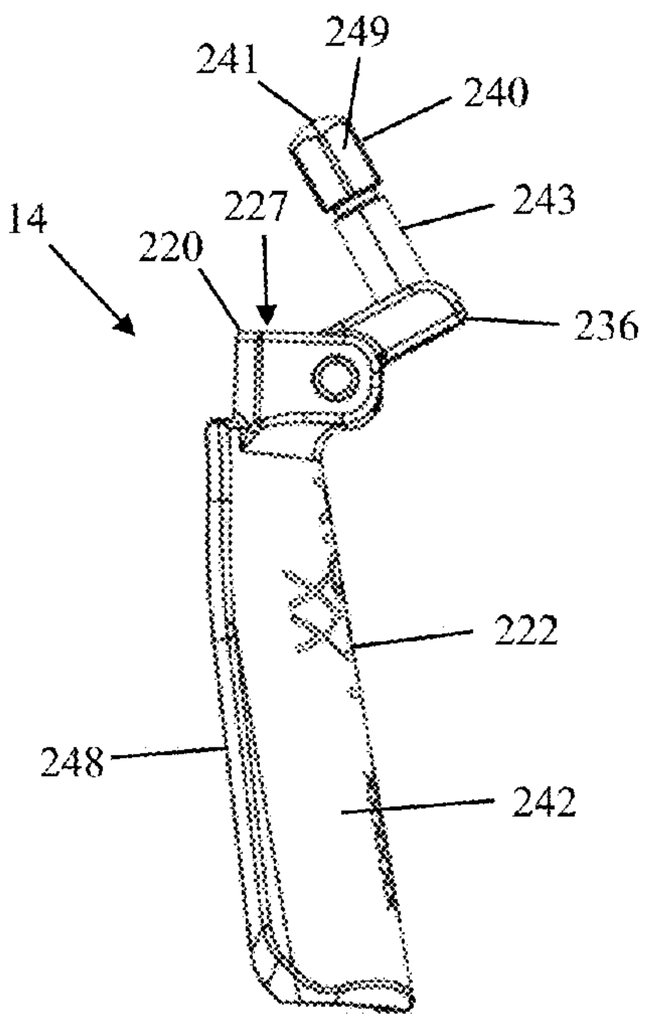


Fig. 24

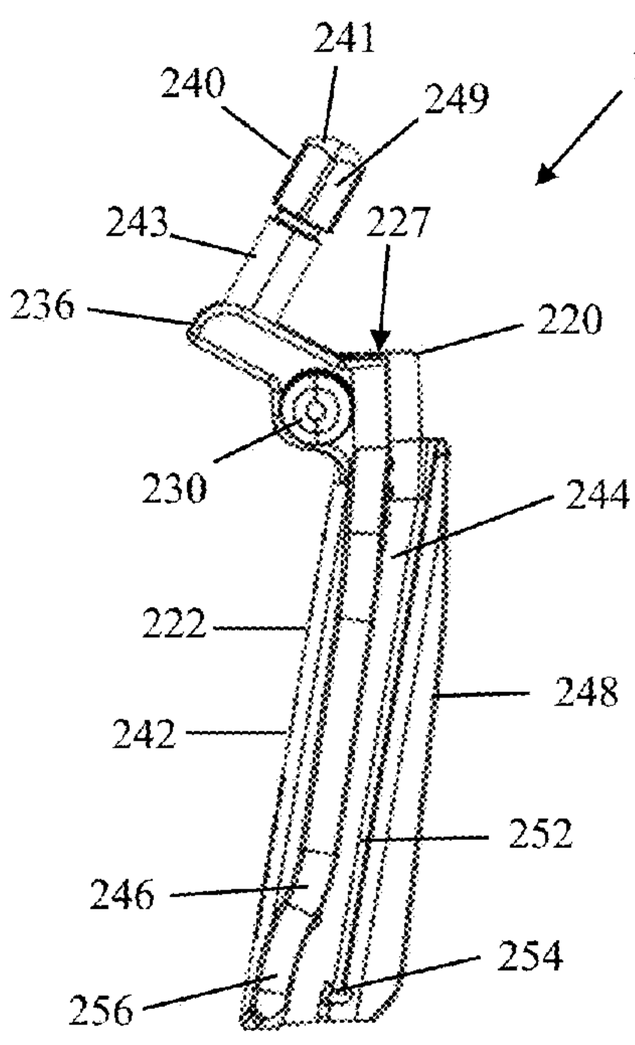


Fig. 25

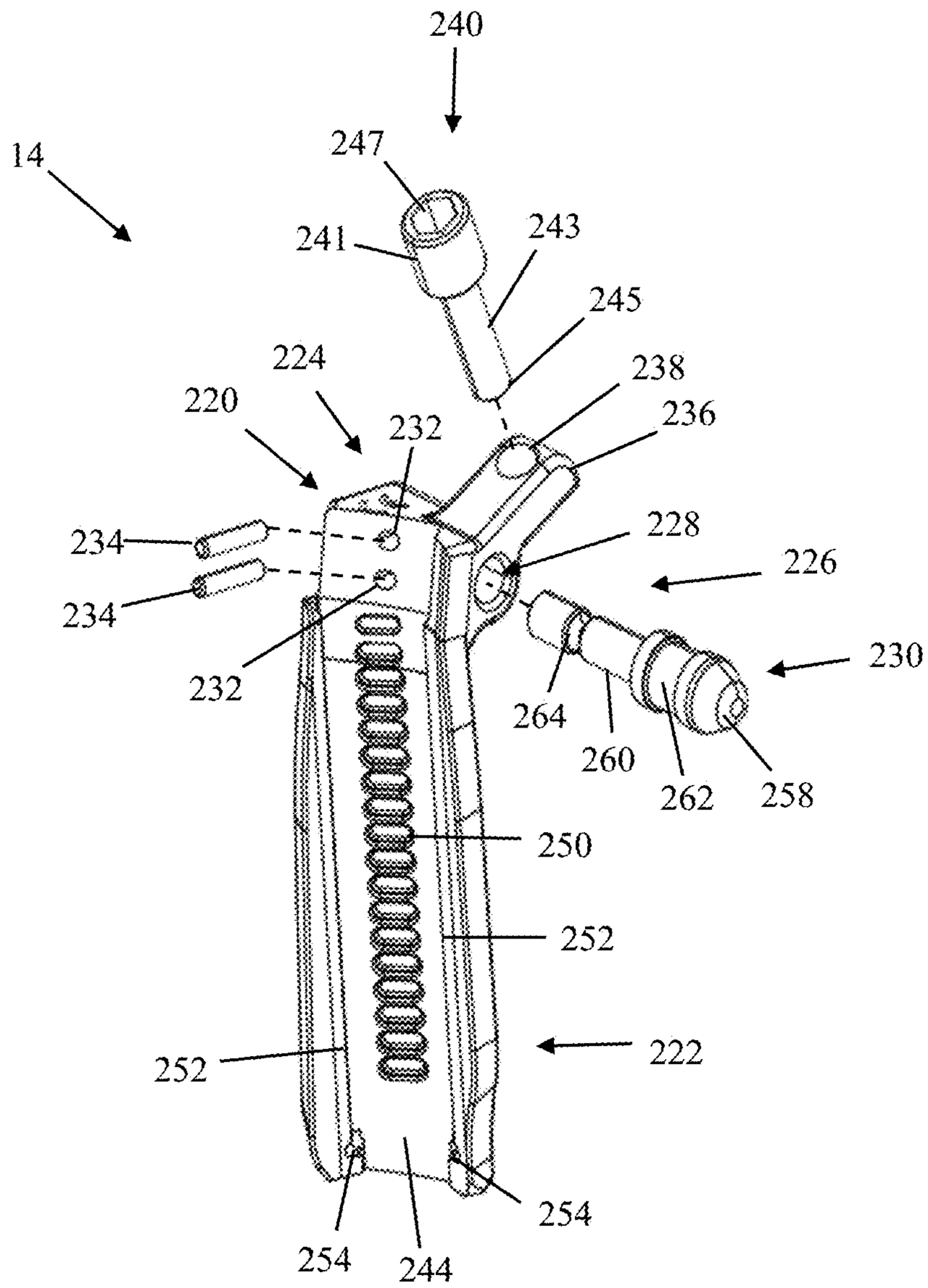

240
14
247
241
243
245
224
238
220
232
236
234
228
226
234
230
232
264
260
262
258
250
252
252
222
254
254
244

Fig. 26

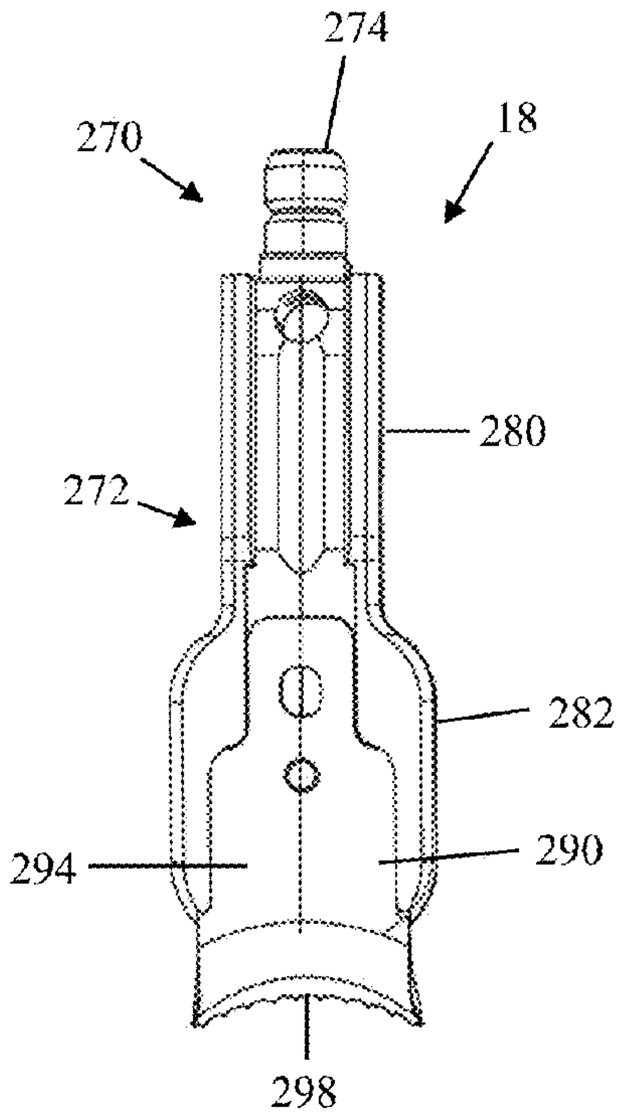


Fig. 27

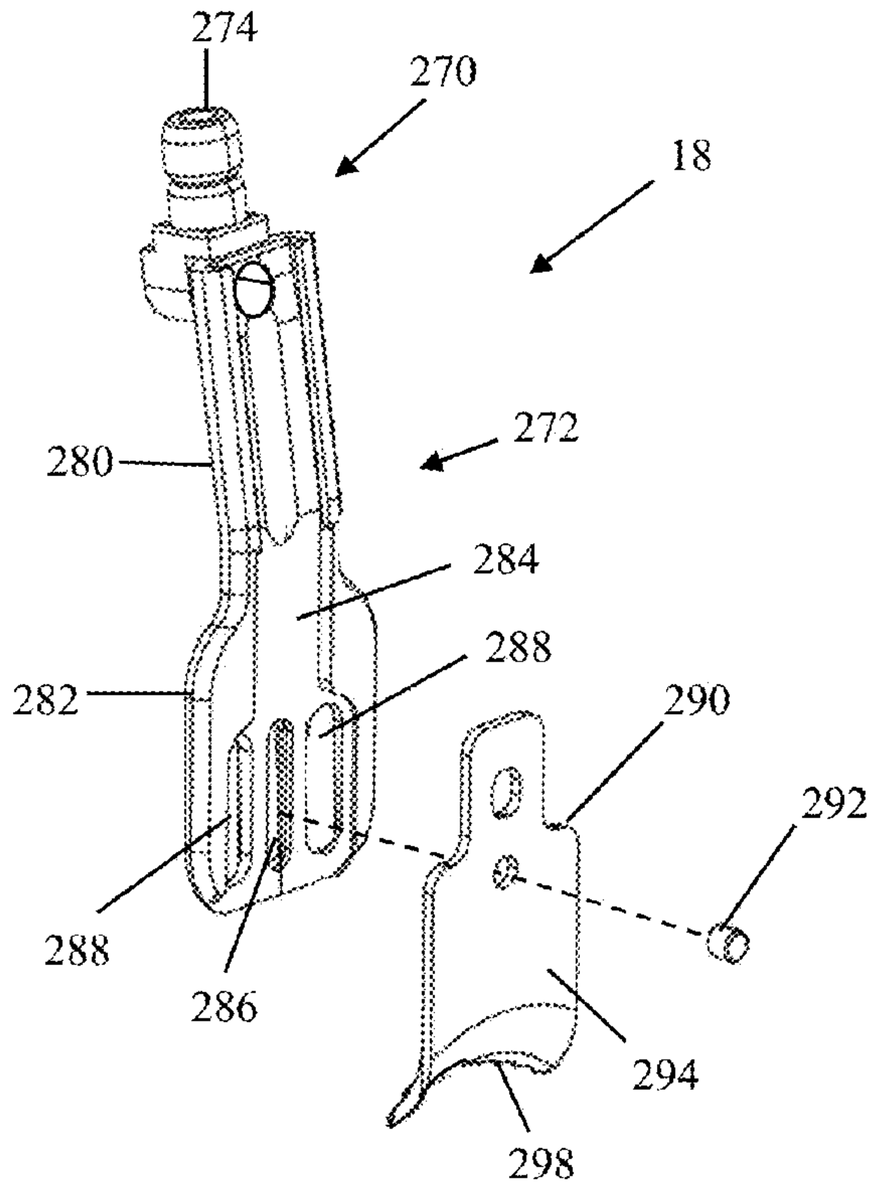


Fig. 28

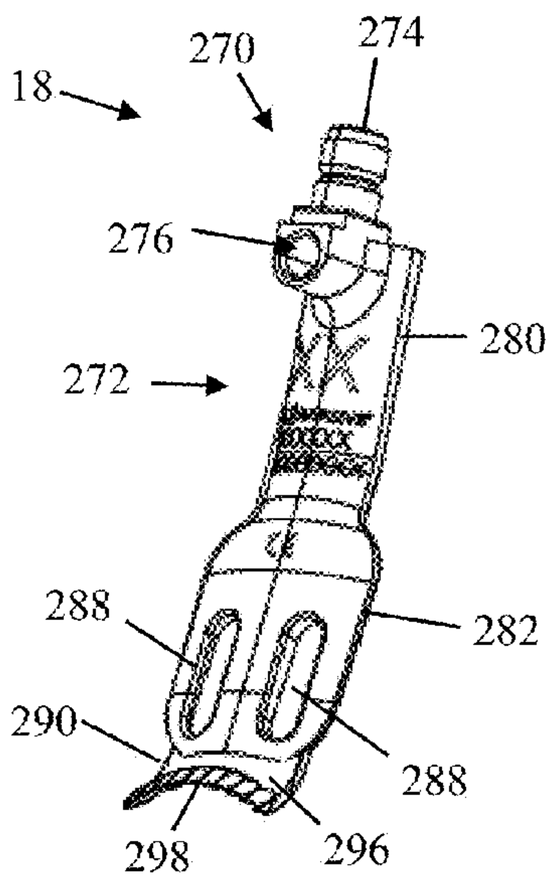


Fig. 29

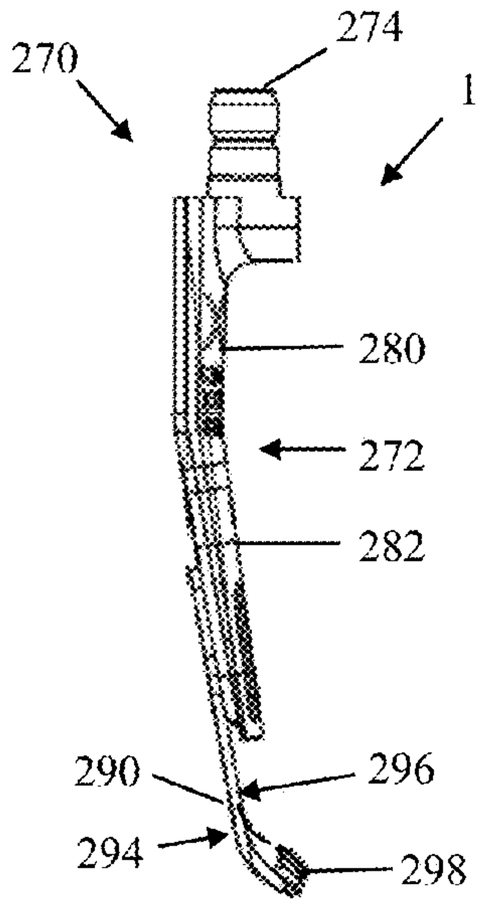


Fig. 30

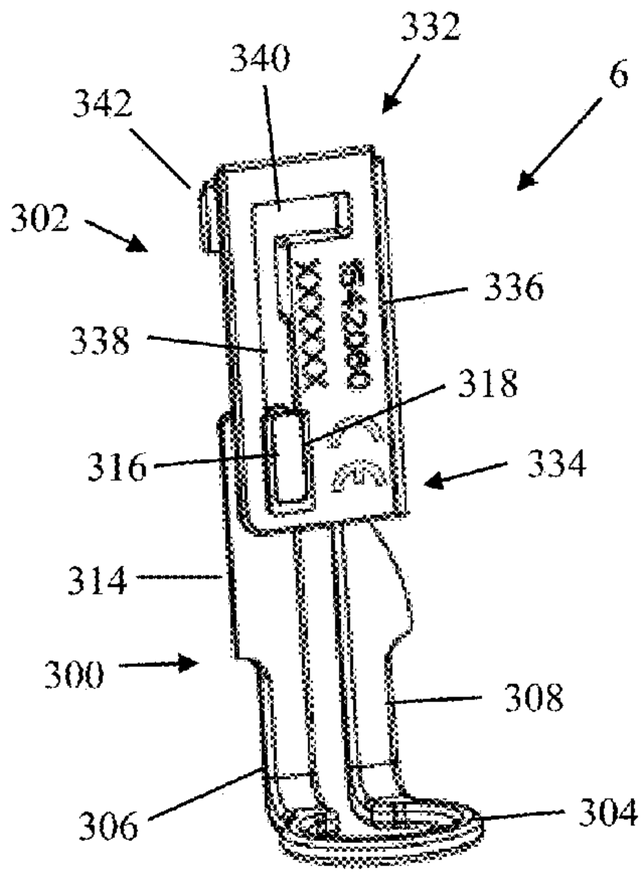


Fig. 31

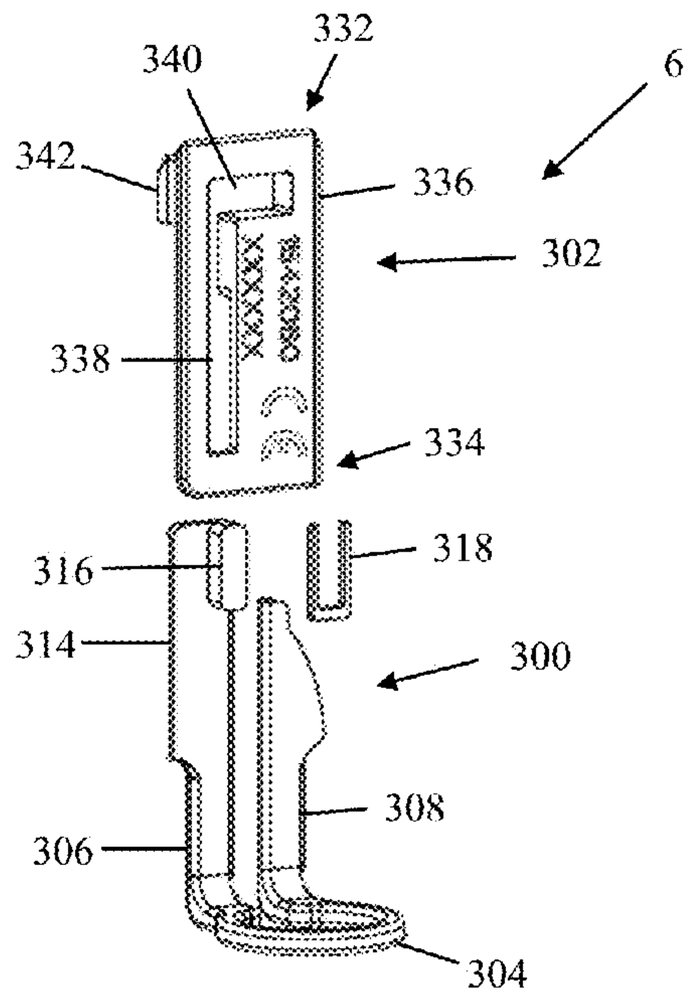


Fig. 32

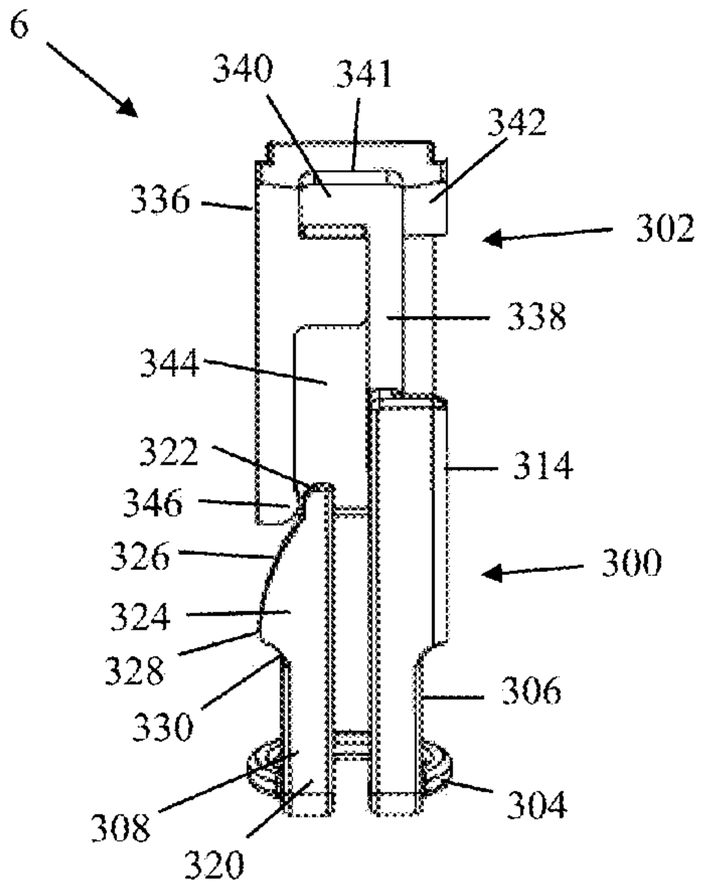


Fig. 33

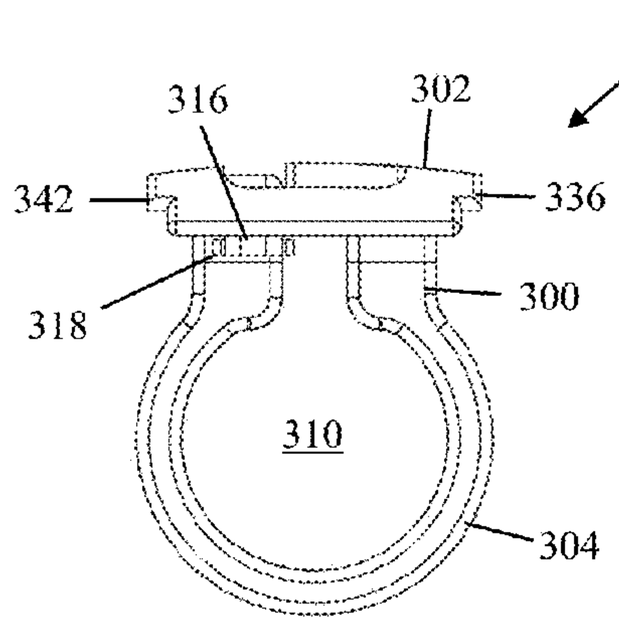


Fig. 34

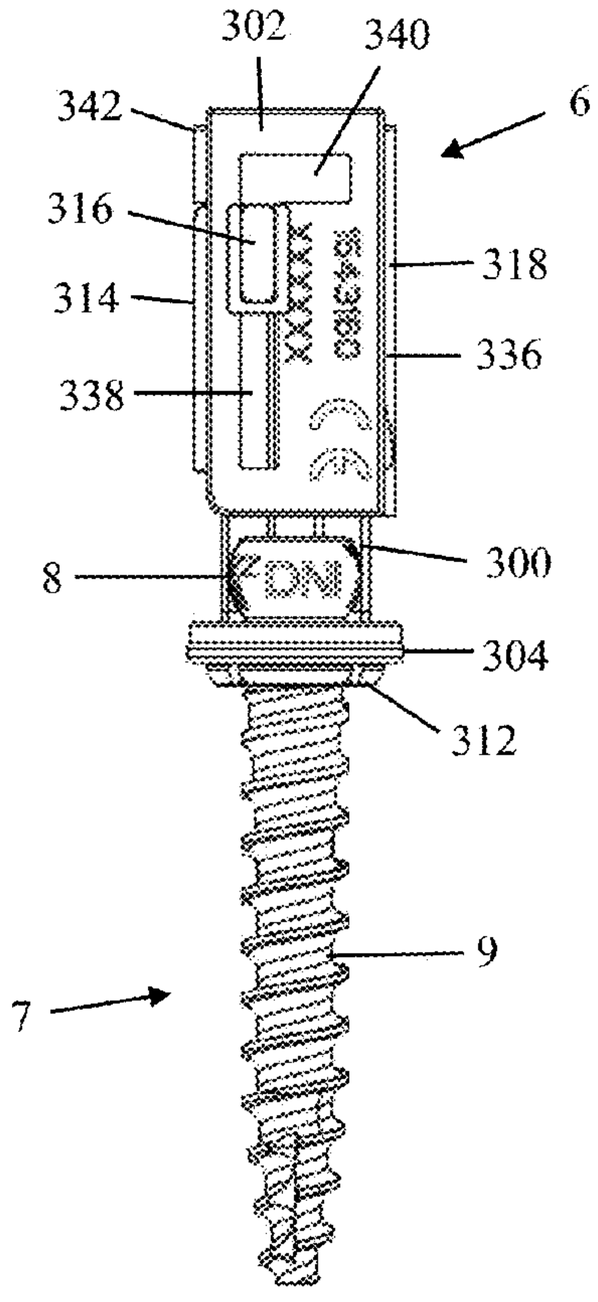


Fig. 35

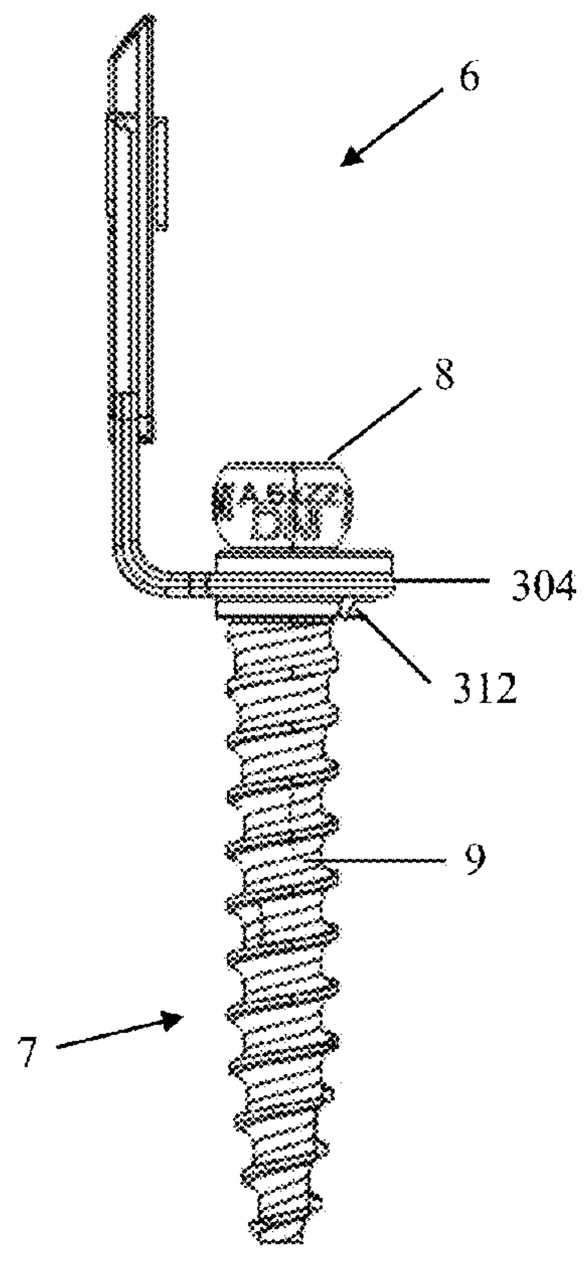


Fig. 36

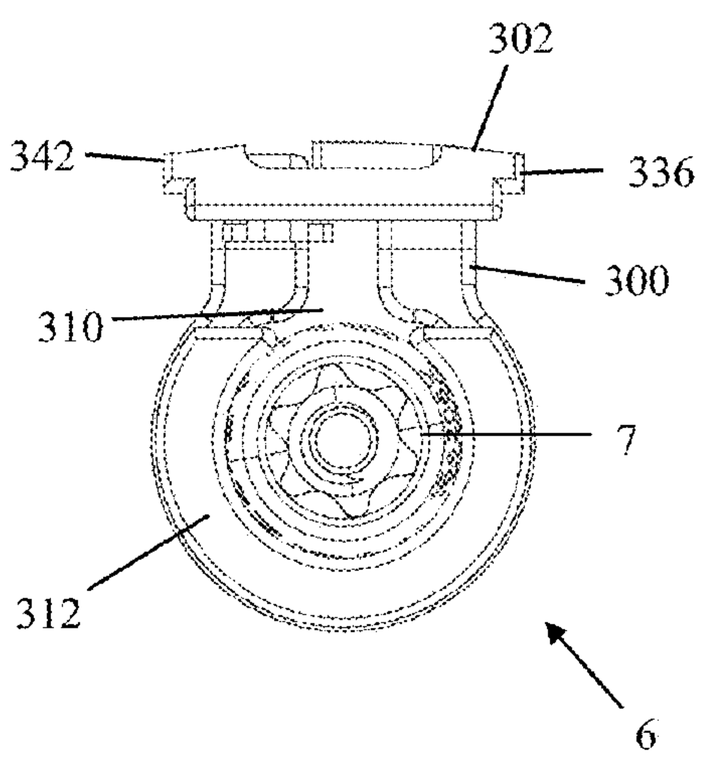


Fig. 37

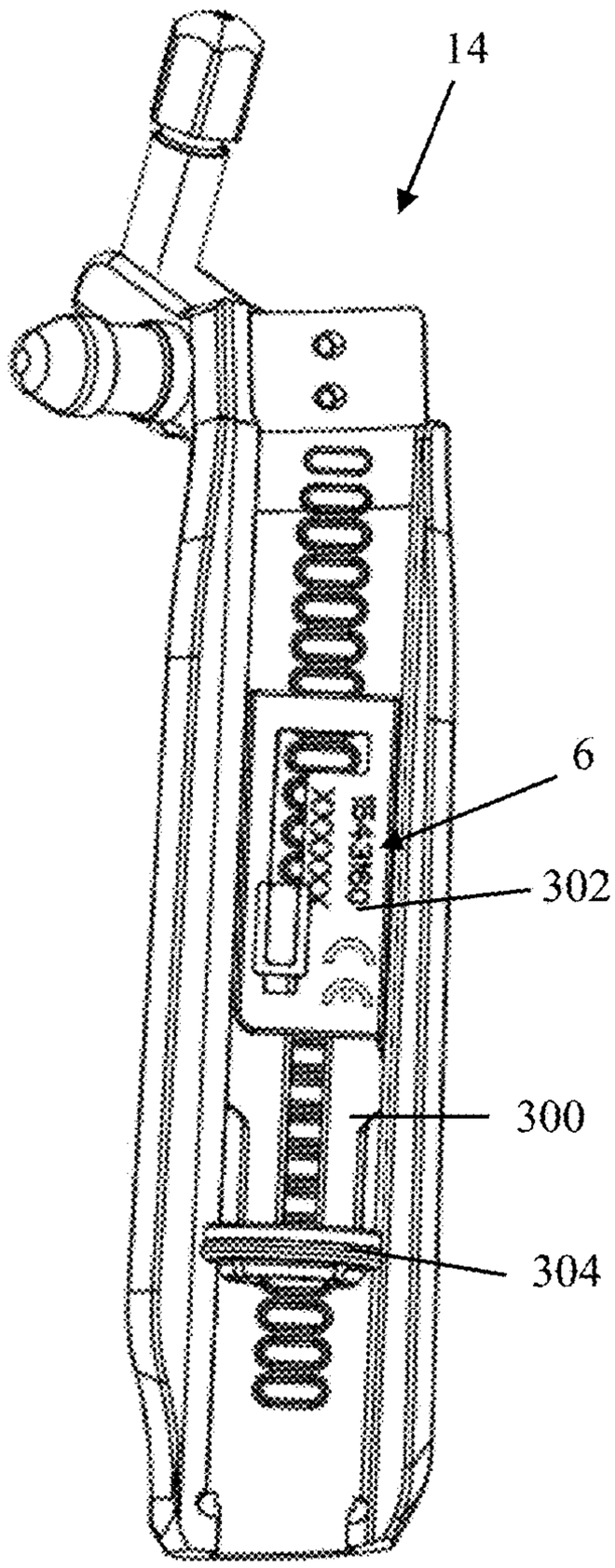


Fig. 38

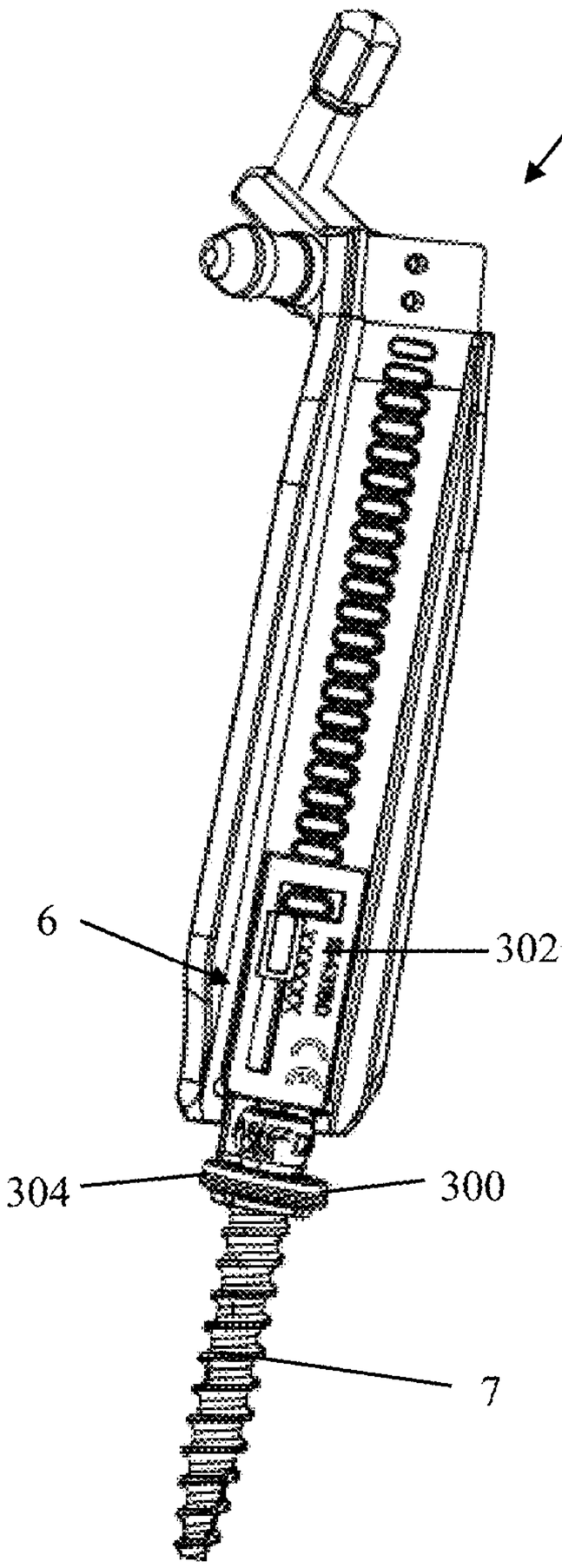


Fig. 39

Fig. 40

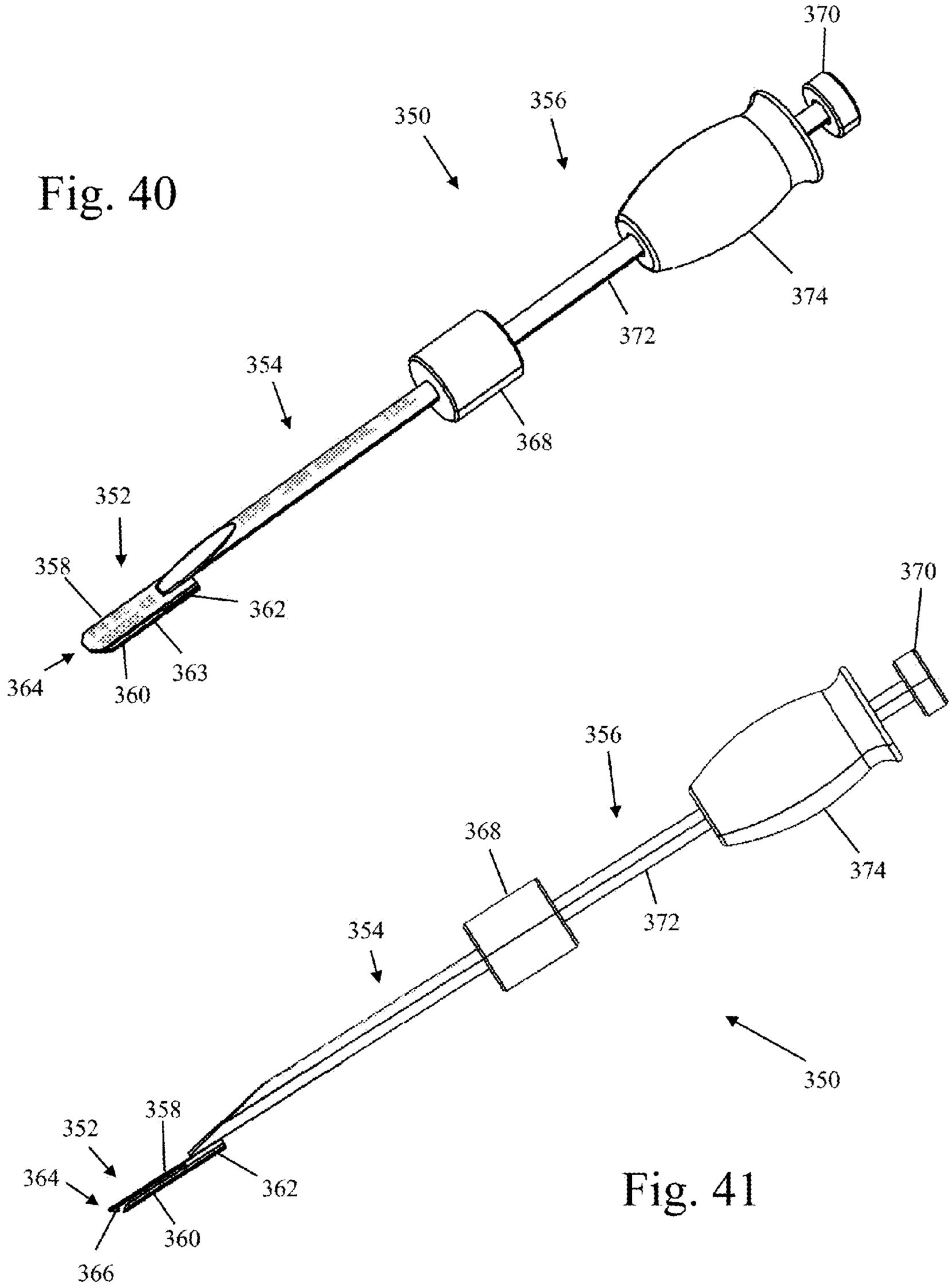

370
350
356
374
372
354
368
352
358
362
364
363
360
370
356
368
374
354
372
352
358
364
362
360
366
350

Fig. 41

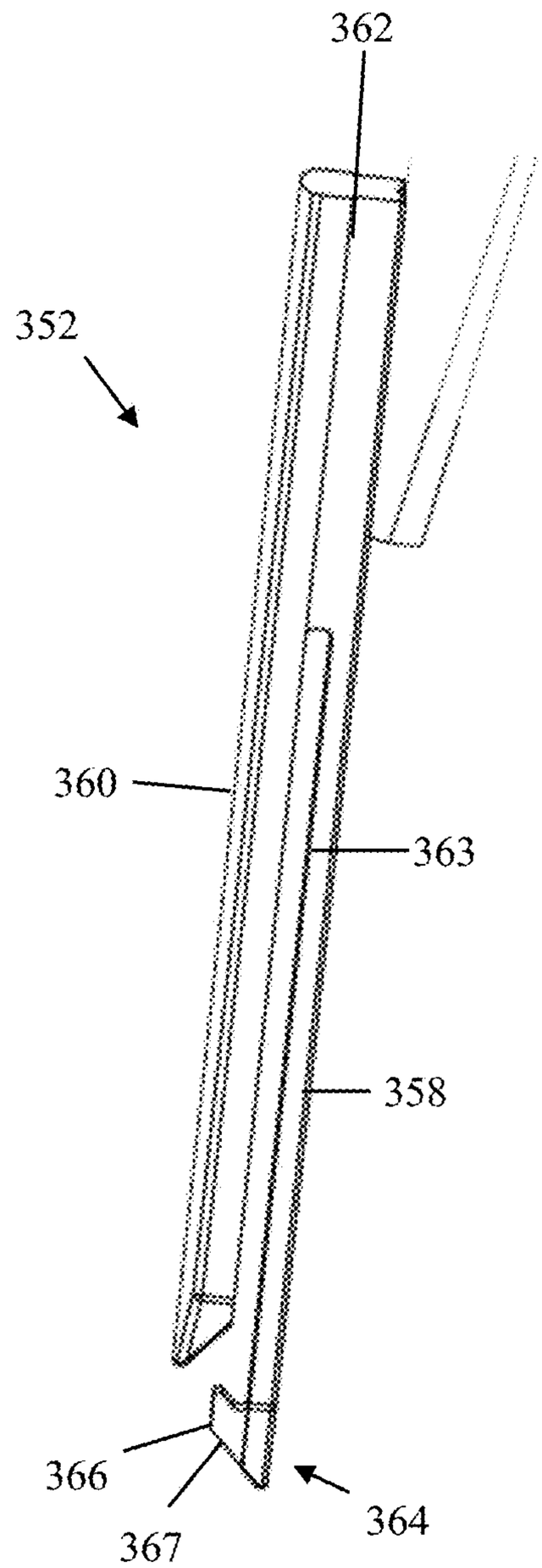


Fig. 42

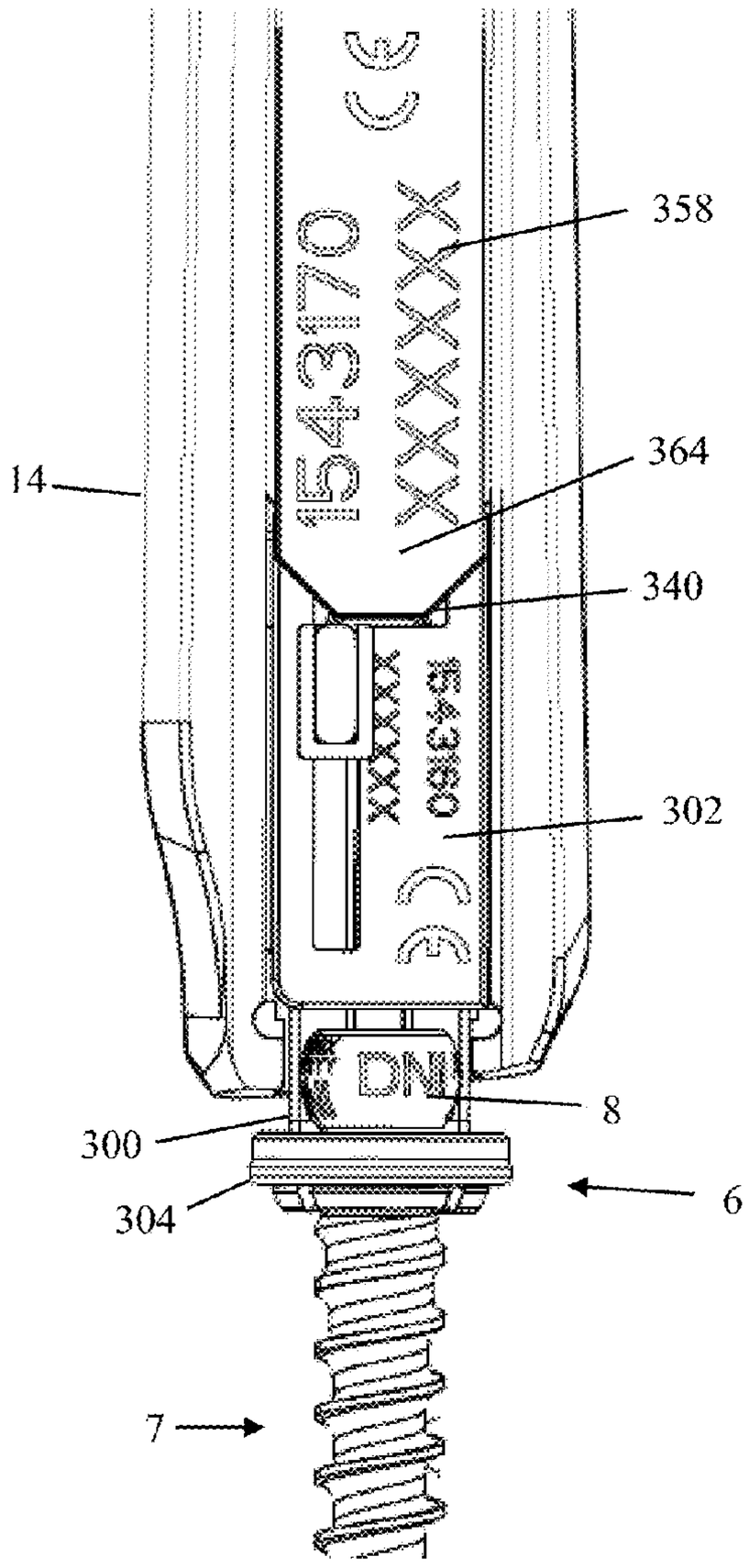

358
364
14
340
302
8
300
304
6
7

Fig. 43

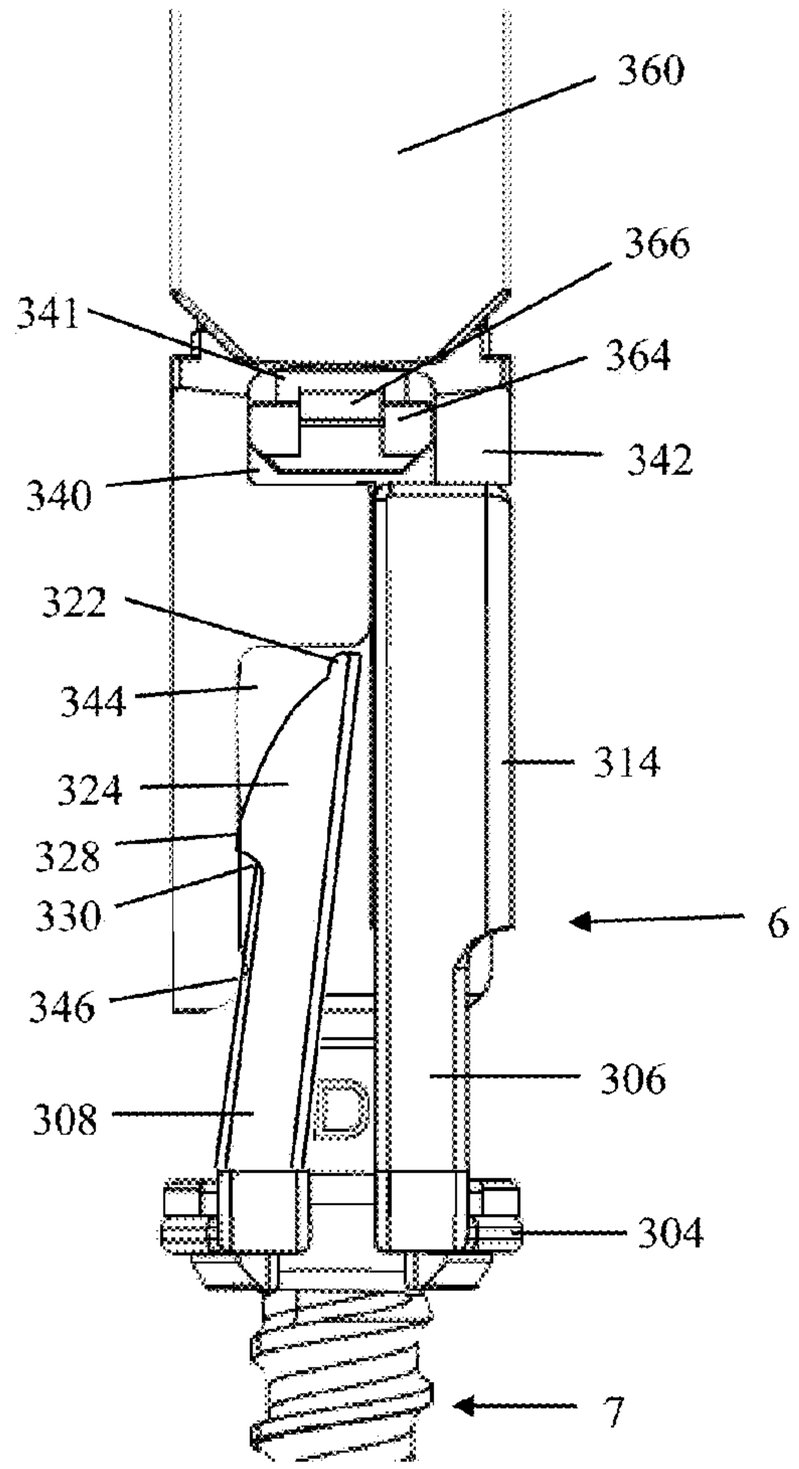

360
366
341
364
342
340
322
344
314
324
328
330
6
346
306
308
304
7

Fig. 44

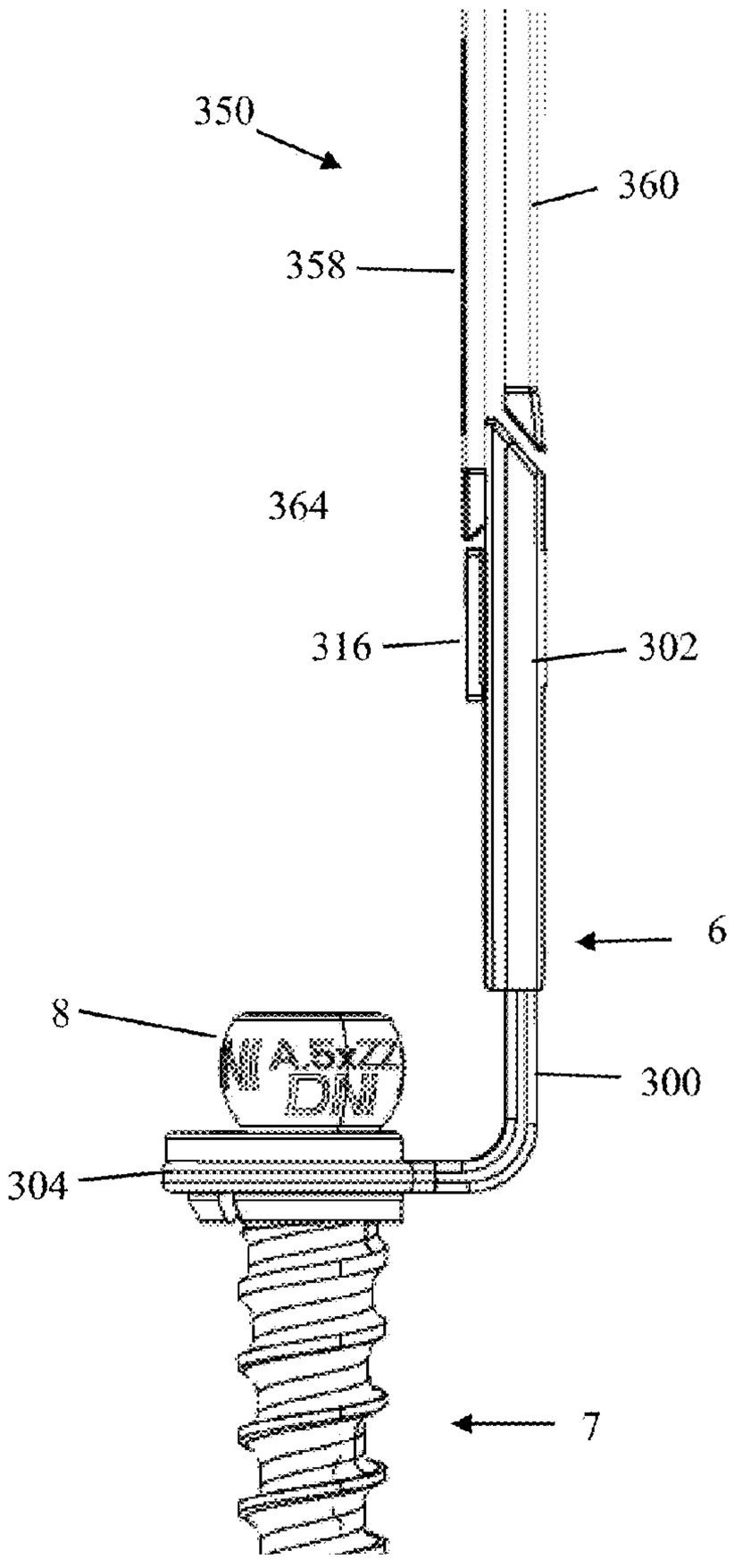

350
360
358
364
316
302
6
8
NA.5xZZ
DM
300
304
7

Fig. 45

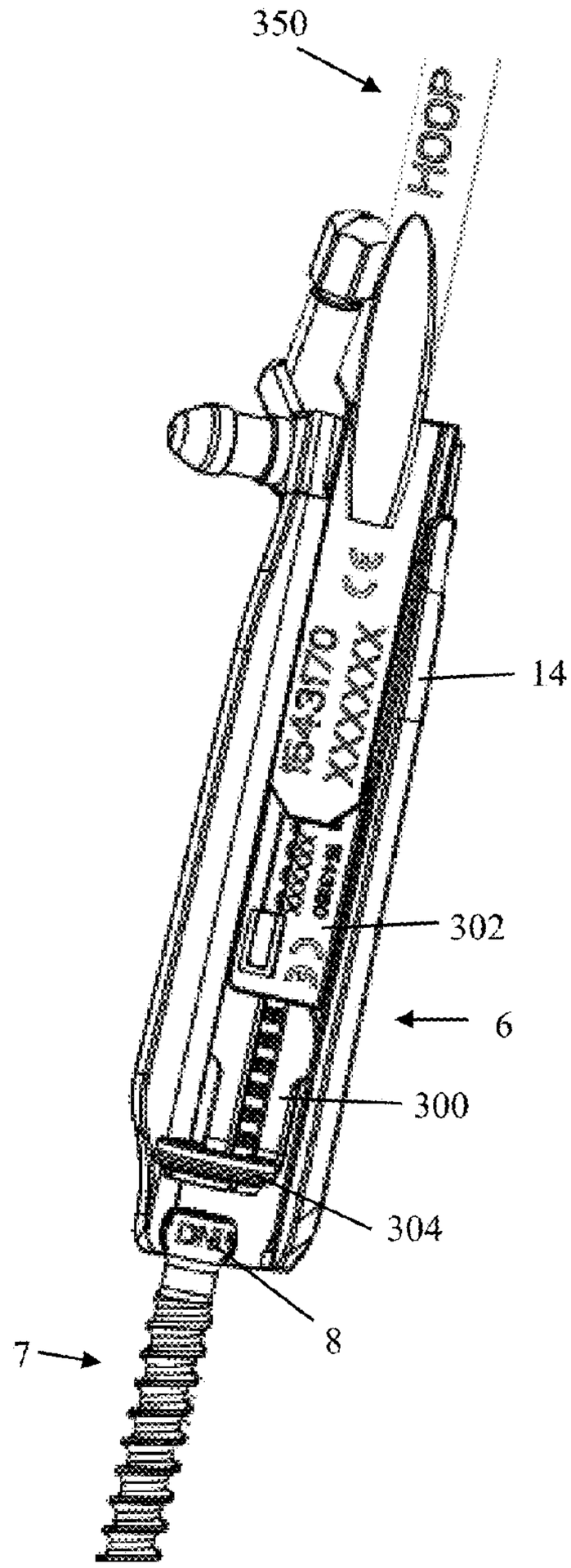

350
Hoop
14
302
6
300
304
8
7

Fig. 46

Fig. 47

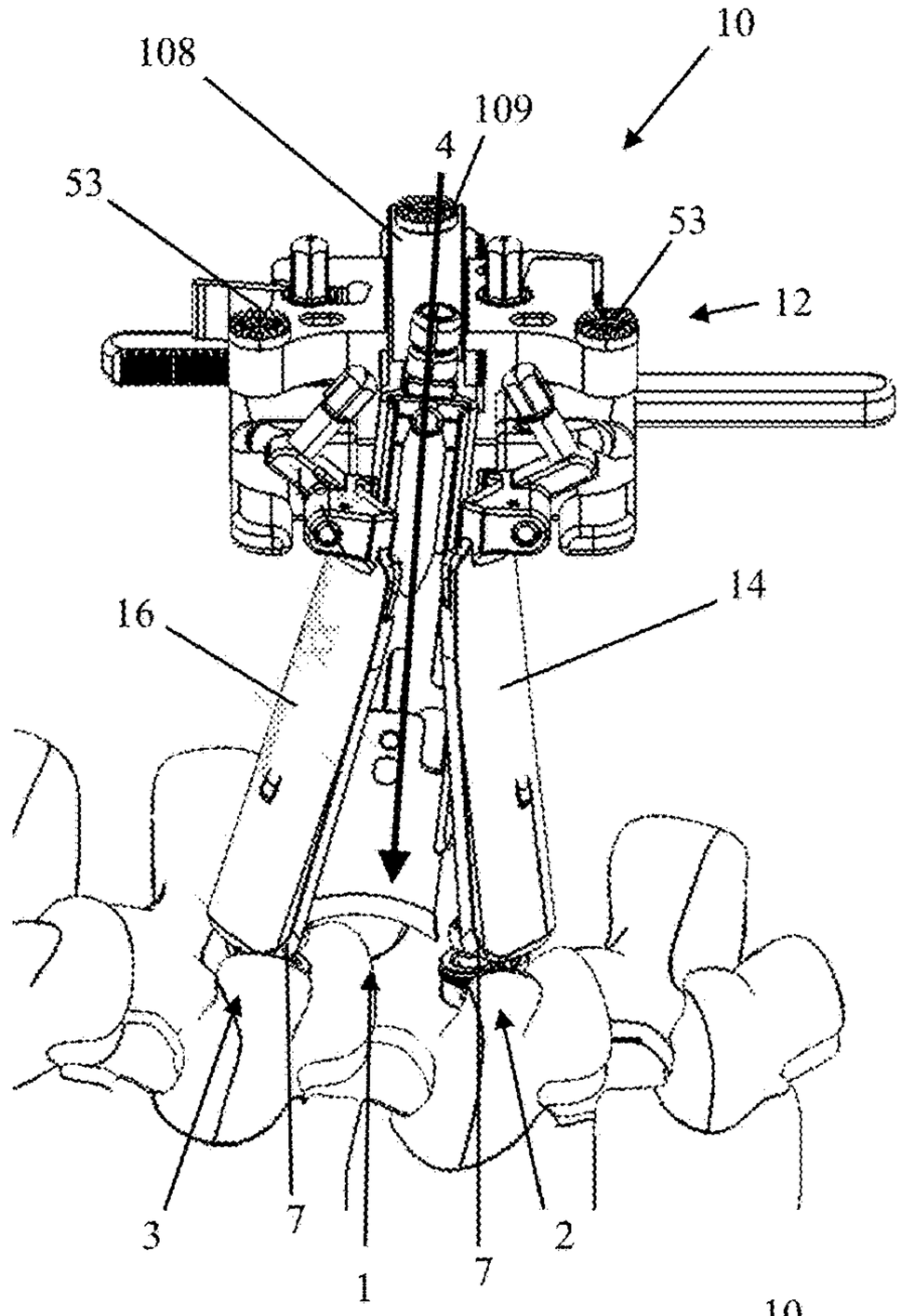
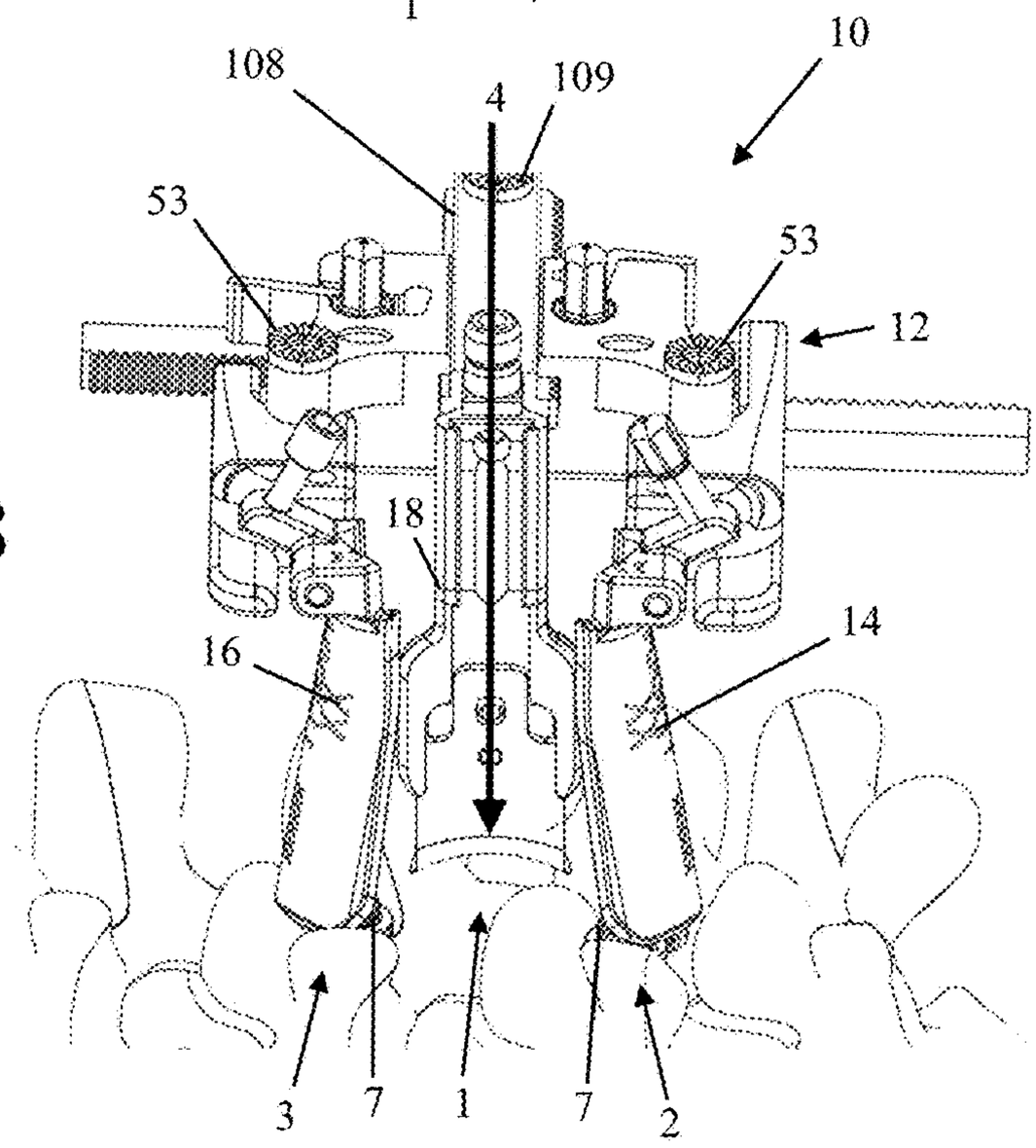

10
108
109
4
53
53
12
14
16
α
α
3
7
1
7
2

Fig. 48


10
108
109
4
53
53
12
18
14
16
3
7
1
7
2

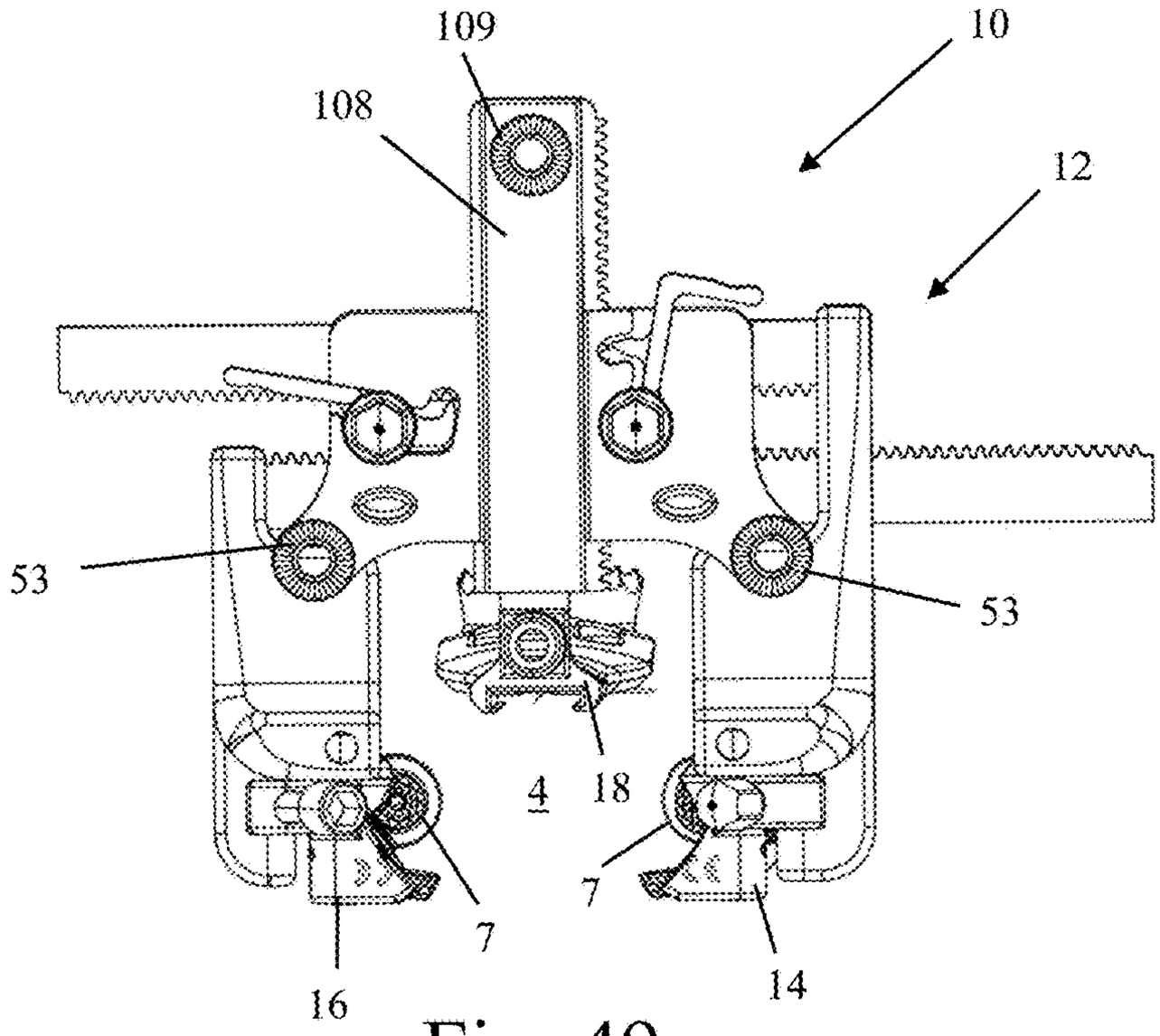


Fig. 49

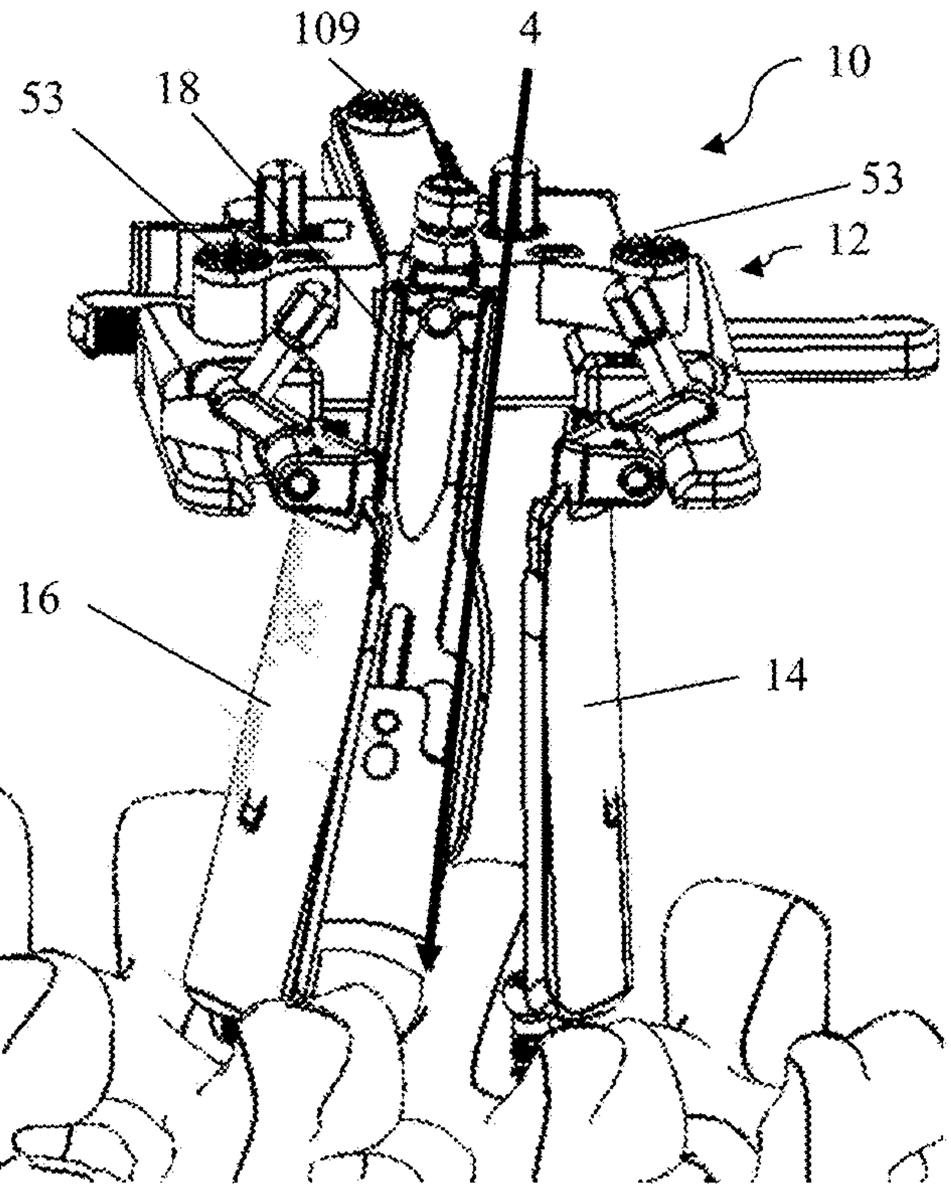


Fig. 50

Fig. 51

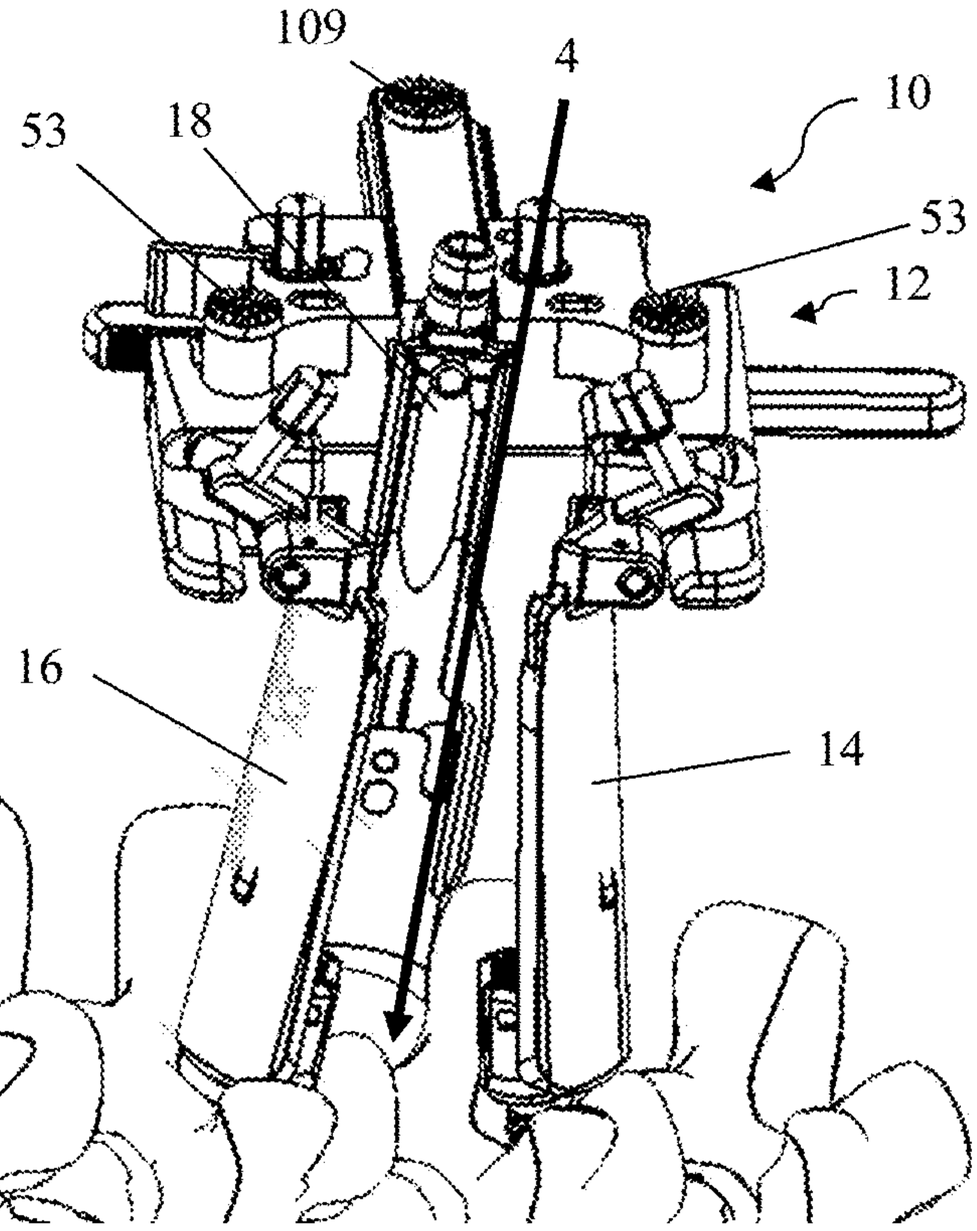


Fig. 52

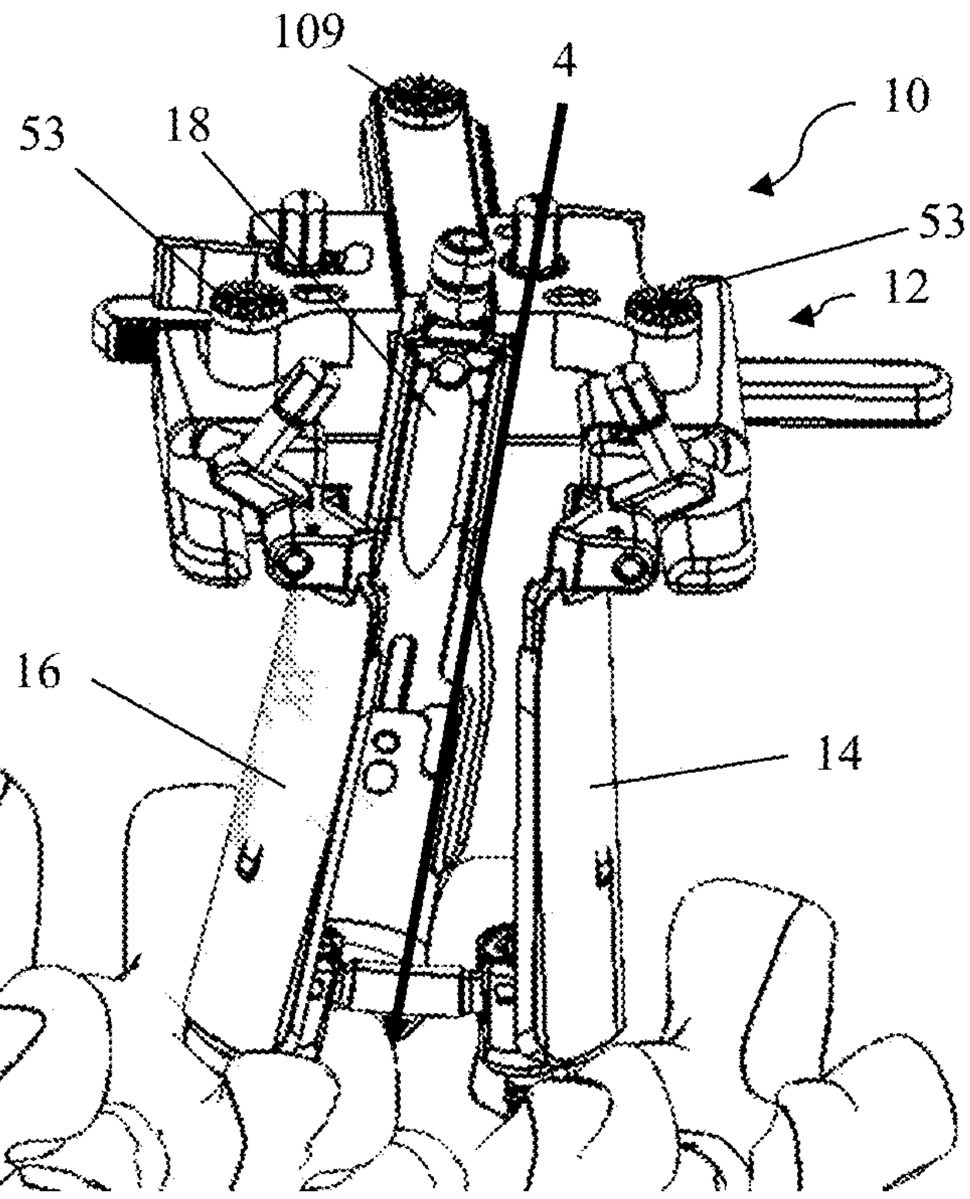
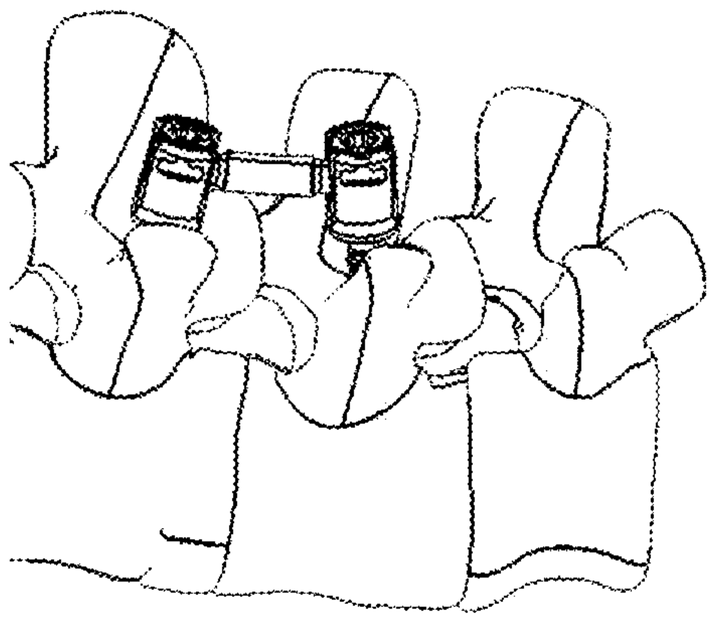


Fig. 53



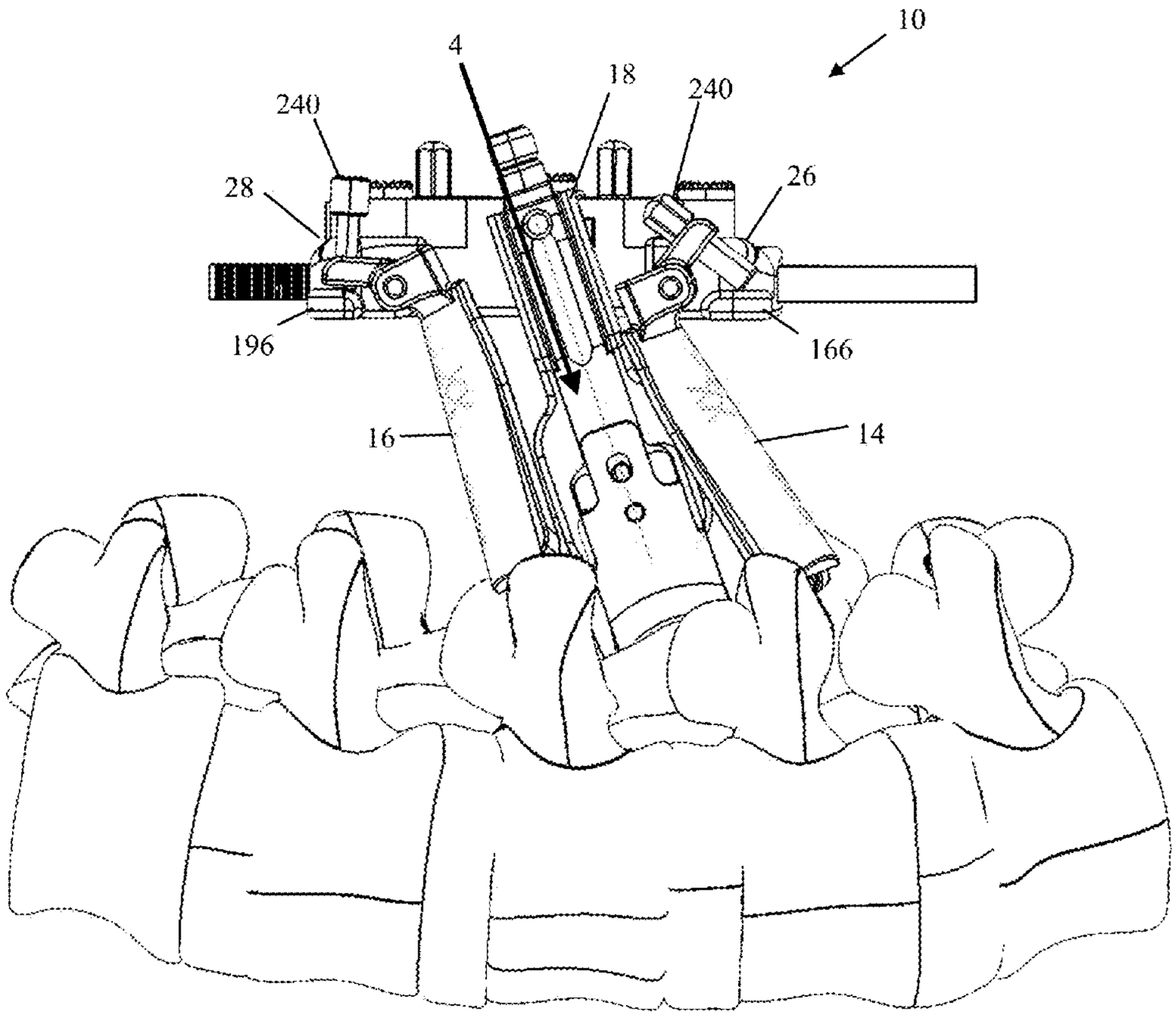


Fig. 54

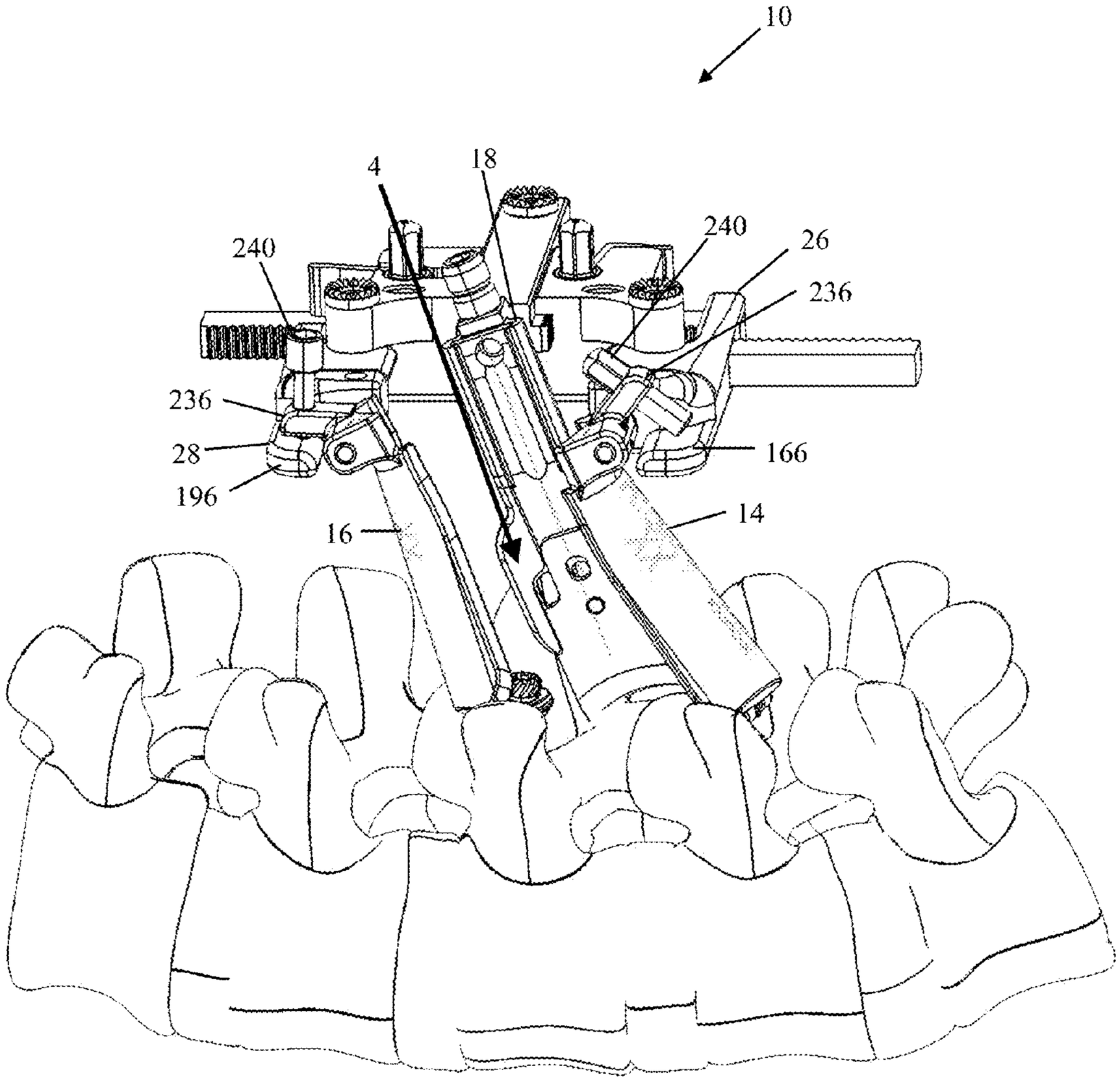


Fig. 55

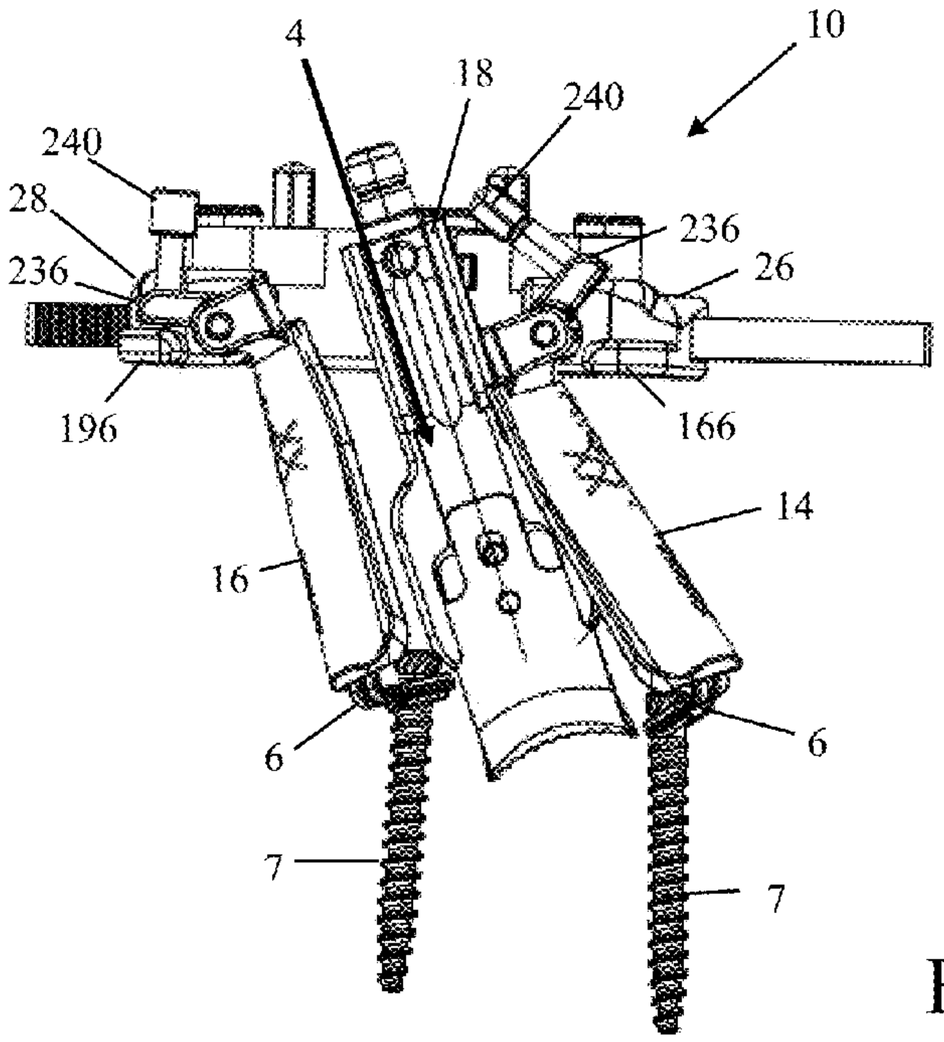

4
10
18
240
240
28
236
236
26
196
166
14
16
6
6
7
7

Fig. 56

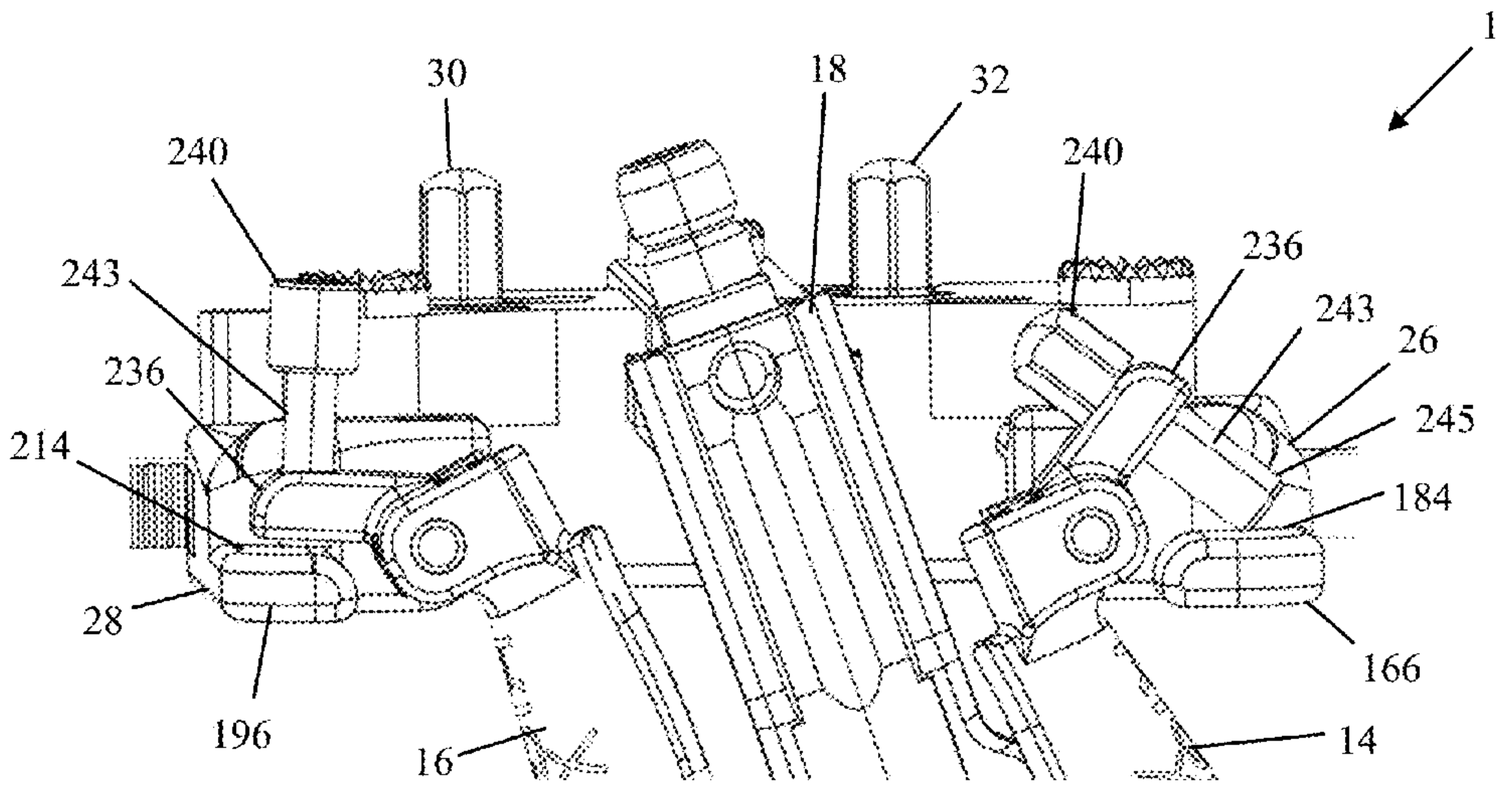

10
30
18
32
240
240
243
236
243
26
236
245
214
184
28
166
196
16
14

Fig. 57

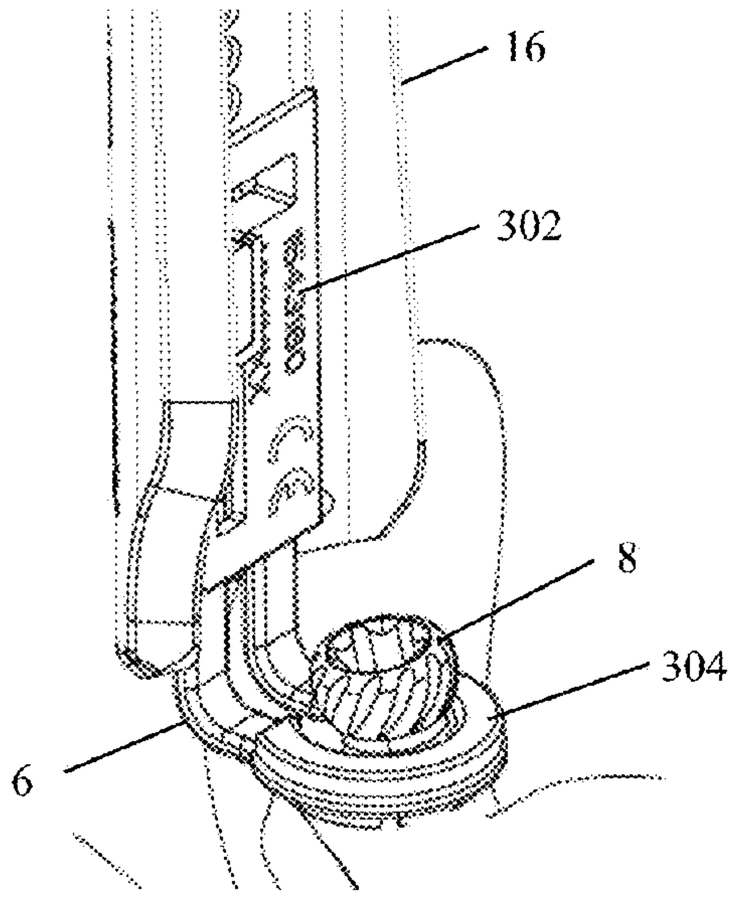


Fig. 58

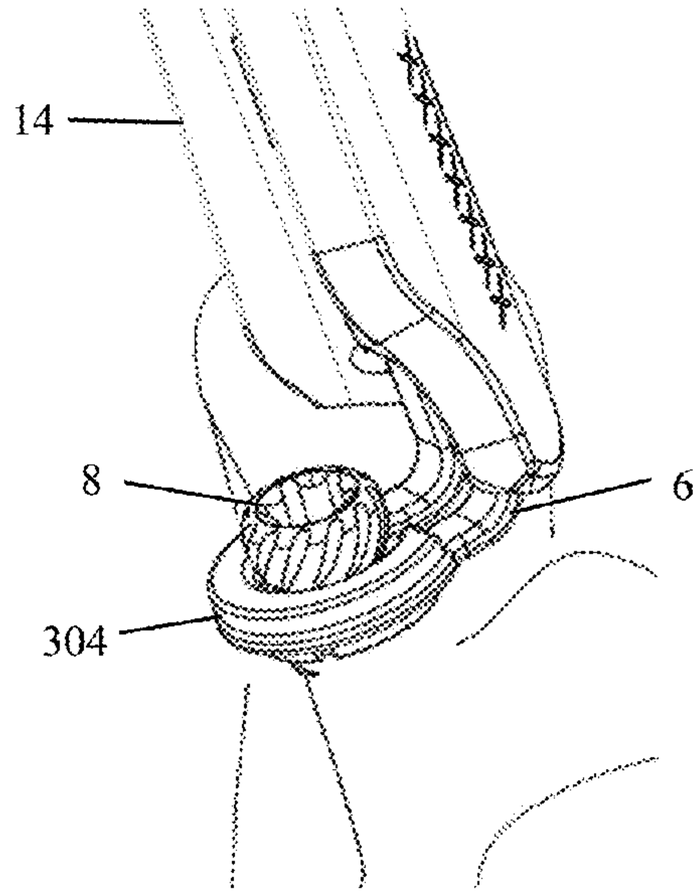


Fig. 59

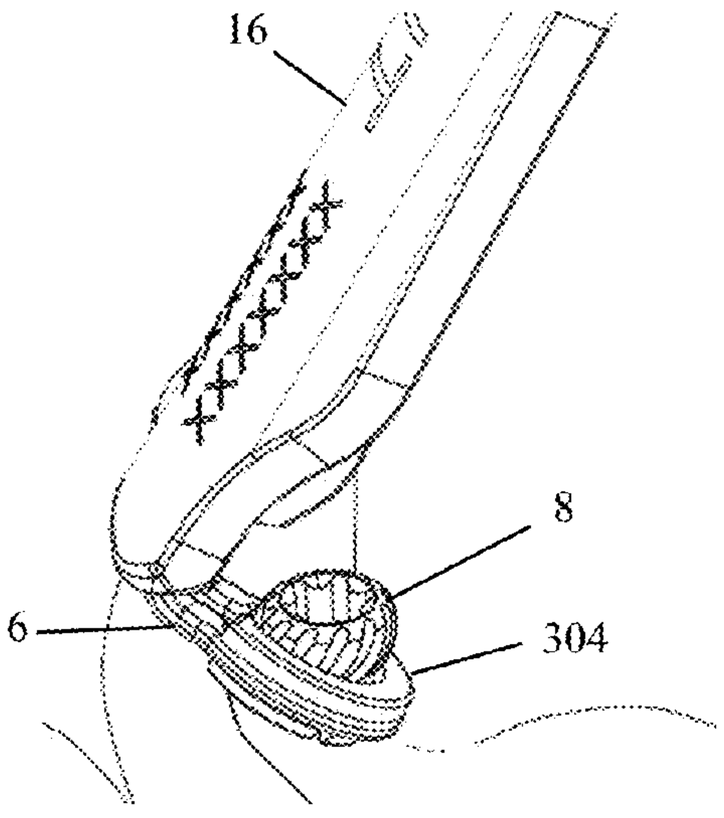


Fig. 60

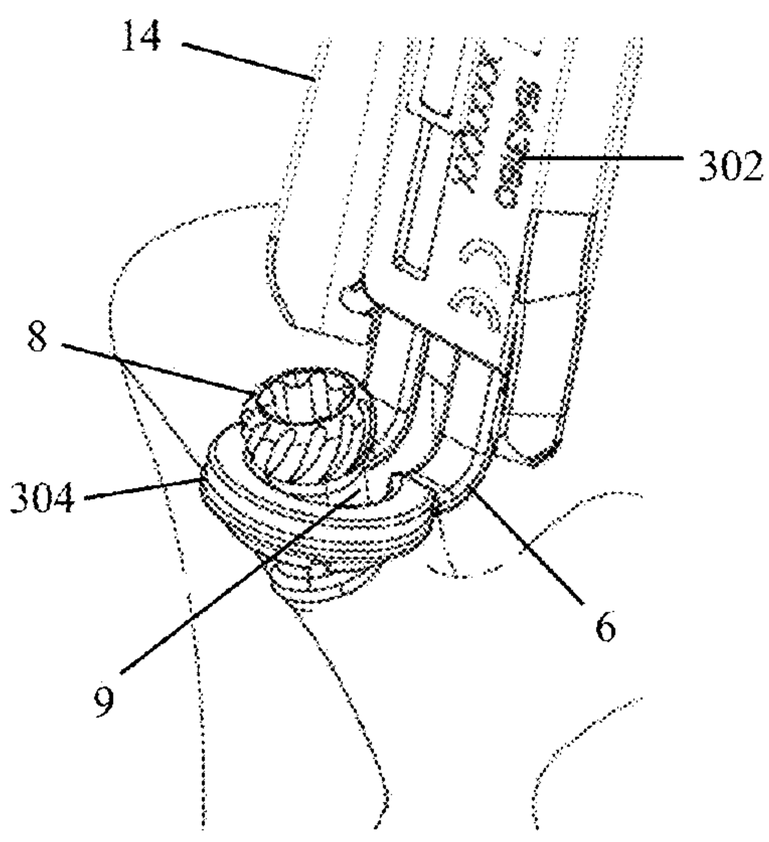


Fig. 61

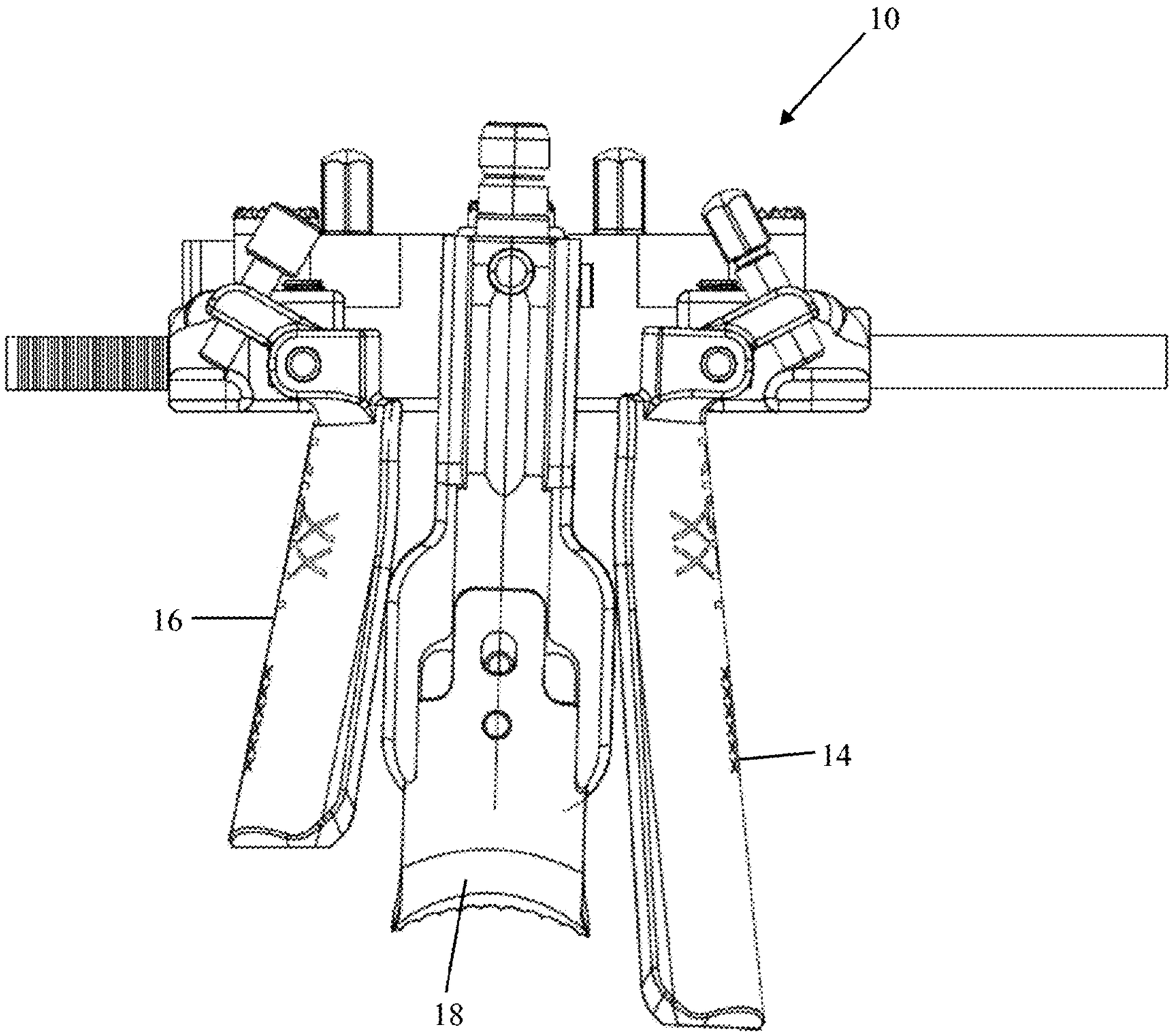


Fig. 62

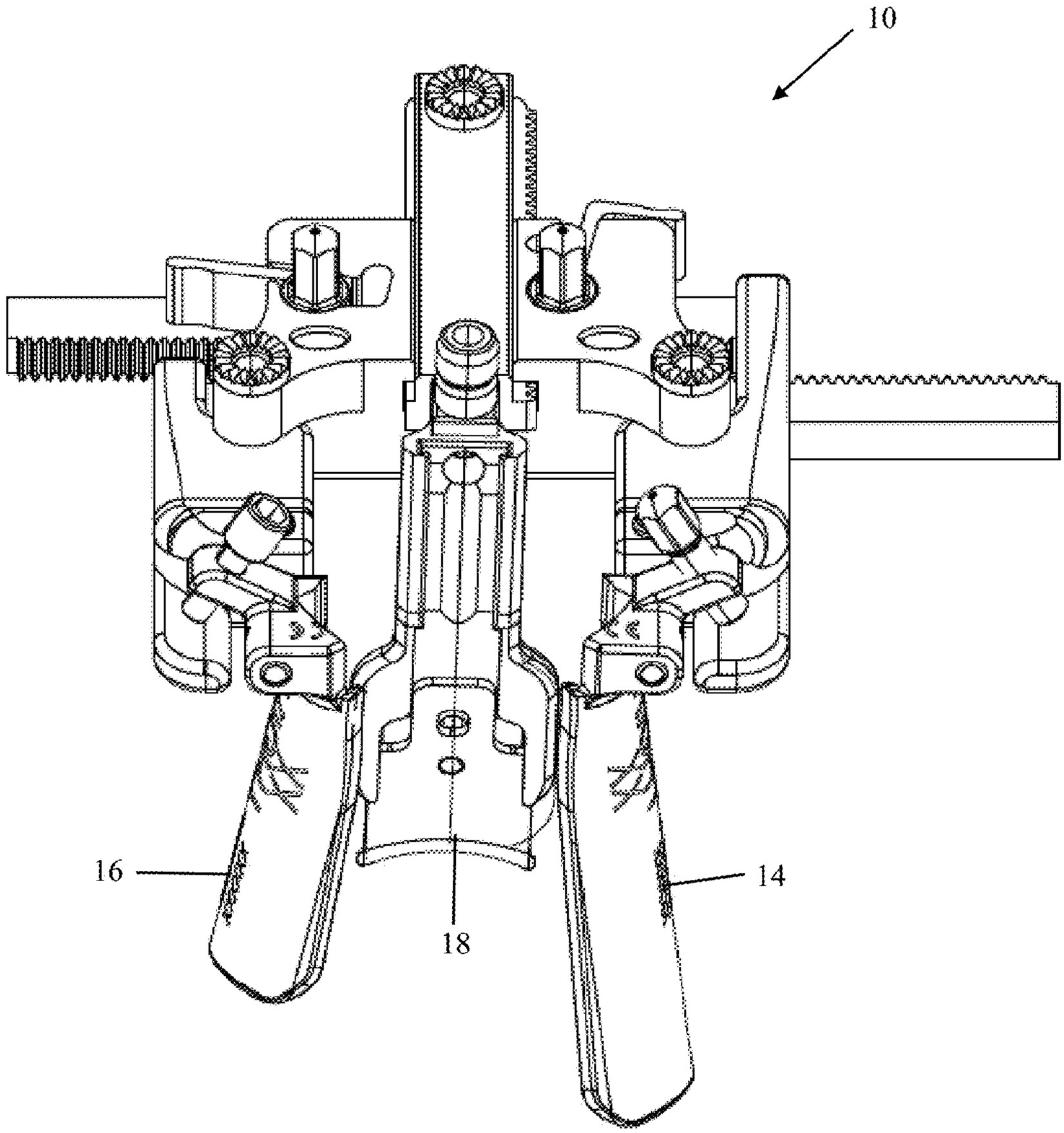


Fig. 63

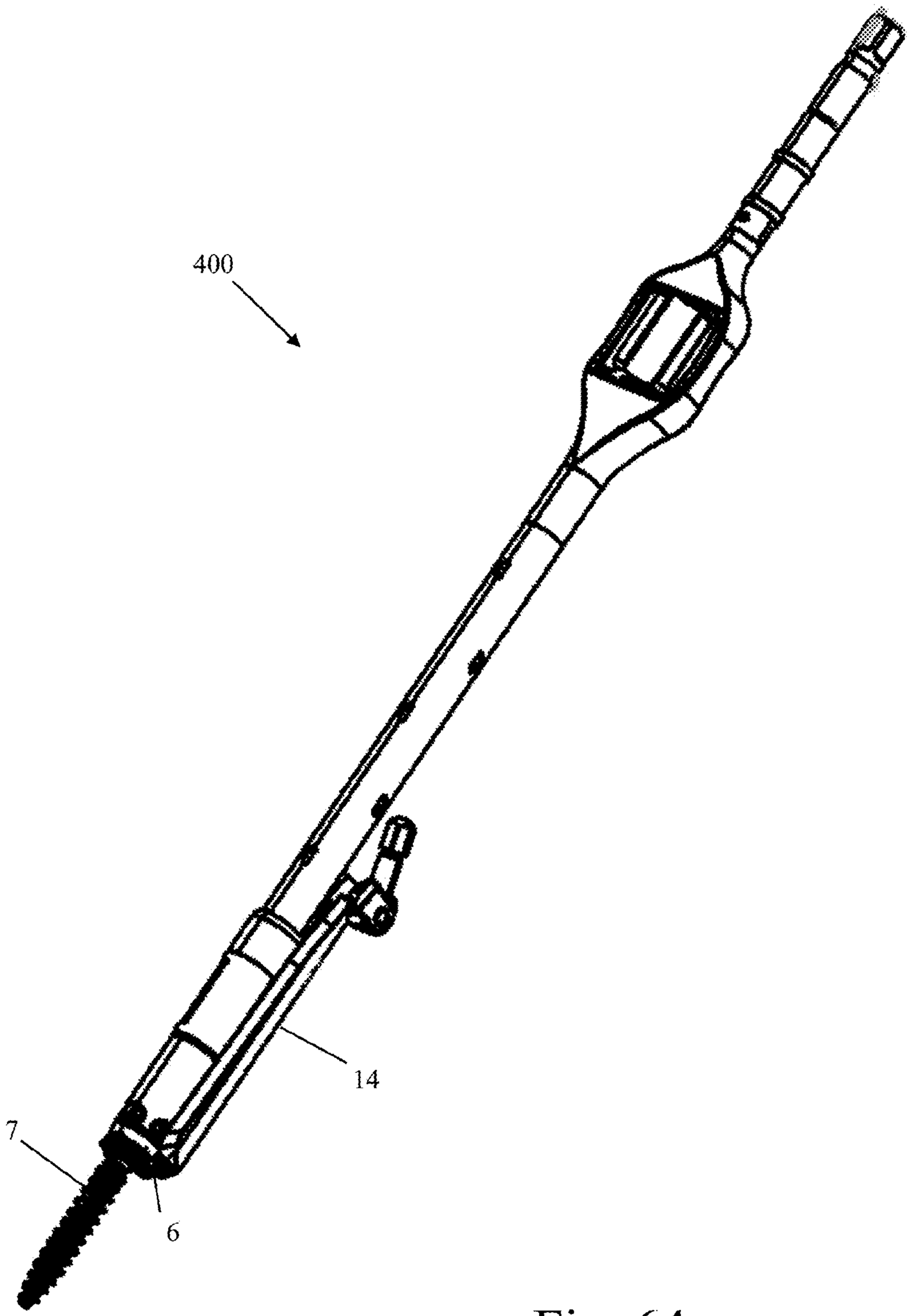


Fig. 64

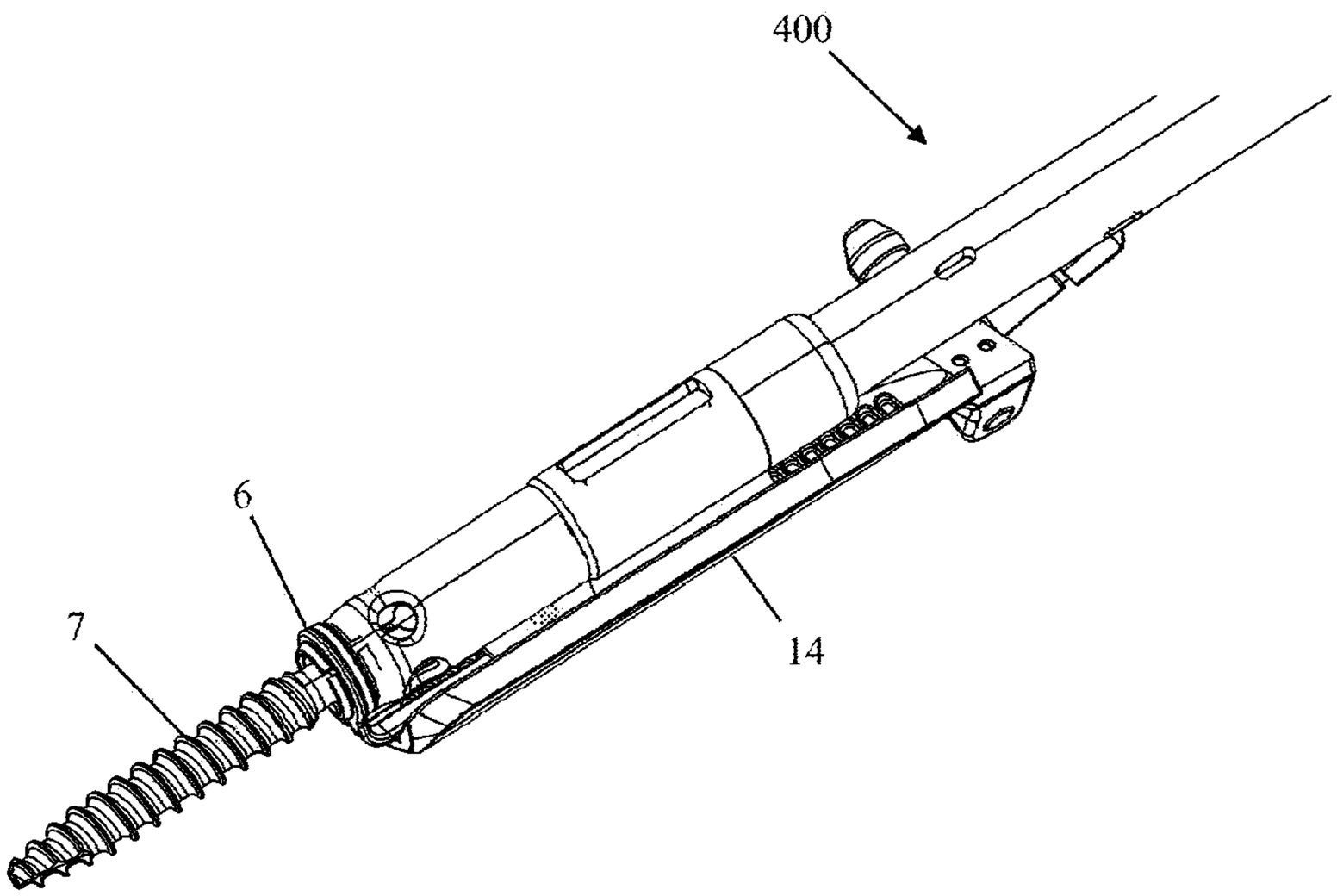


Fig. 65

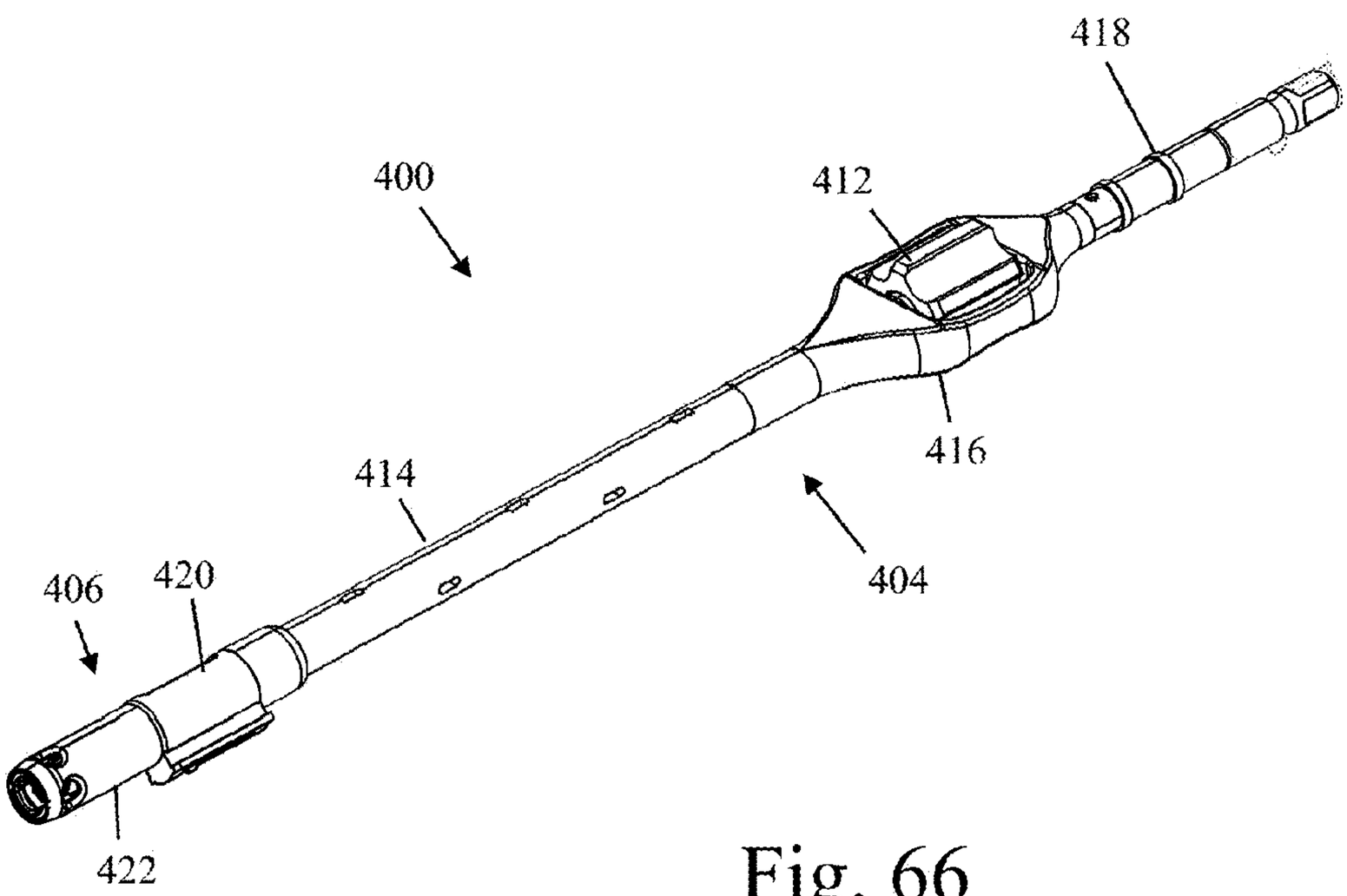


Fig. 66

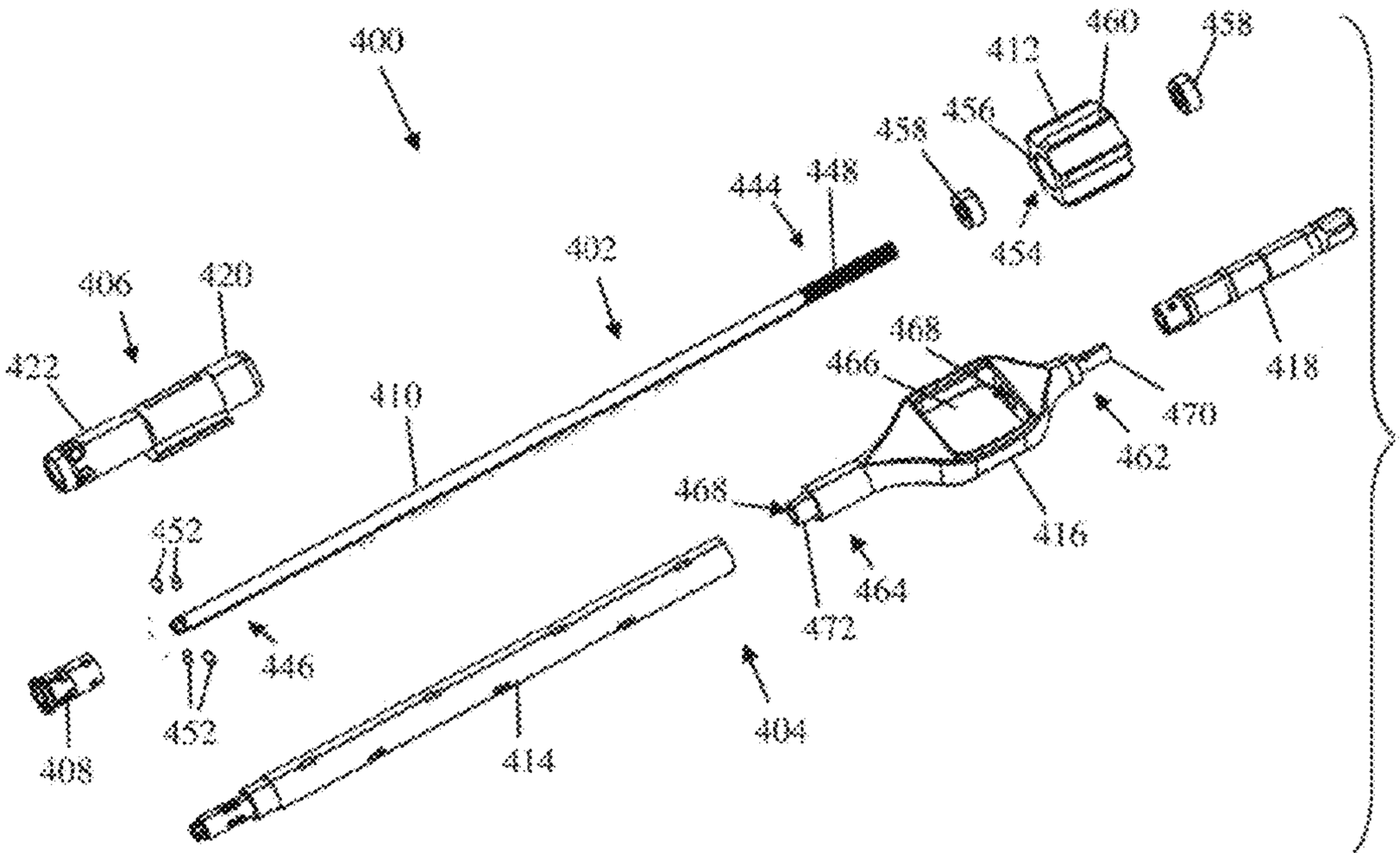


Fig. 67

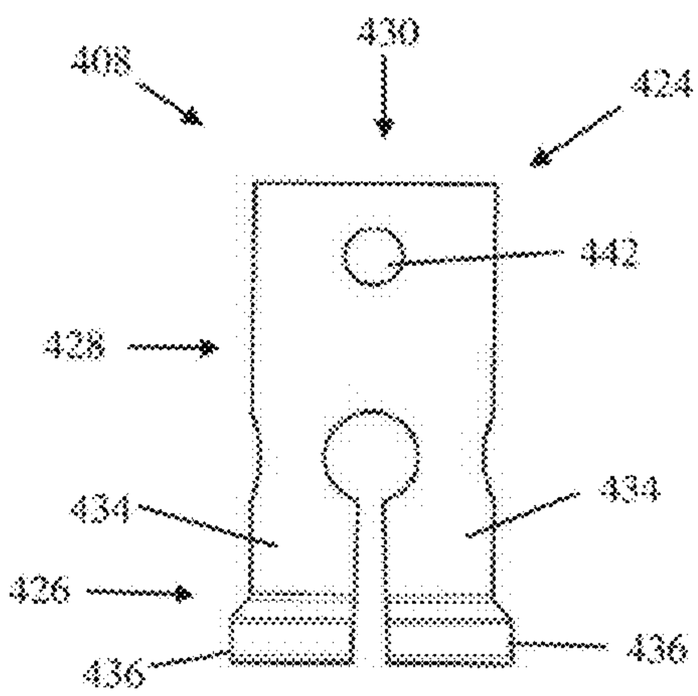


Fig. 68

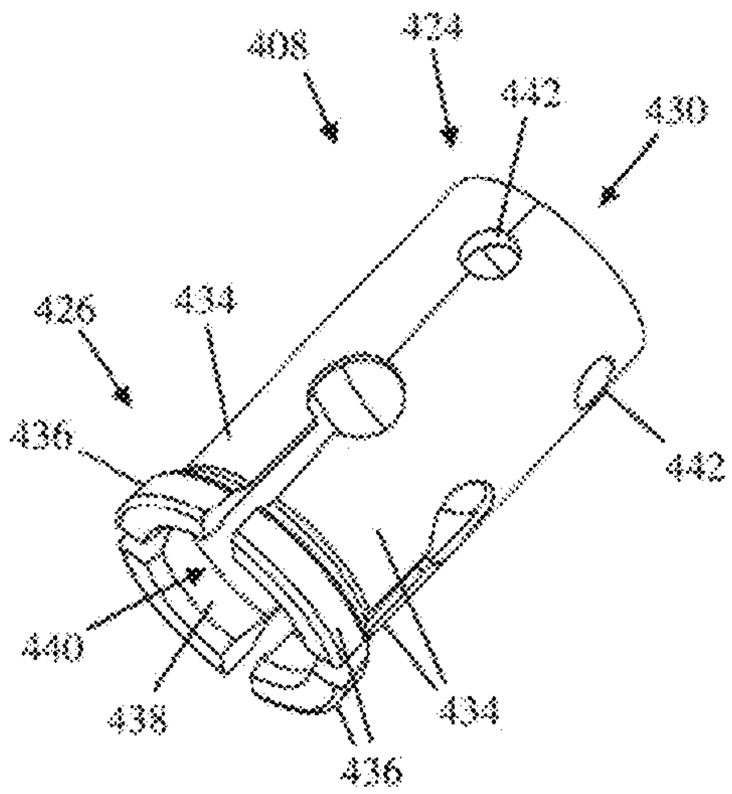


Fig. 69

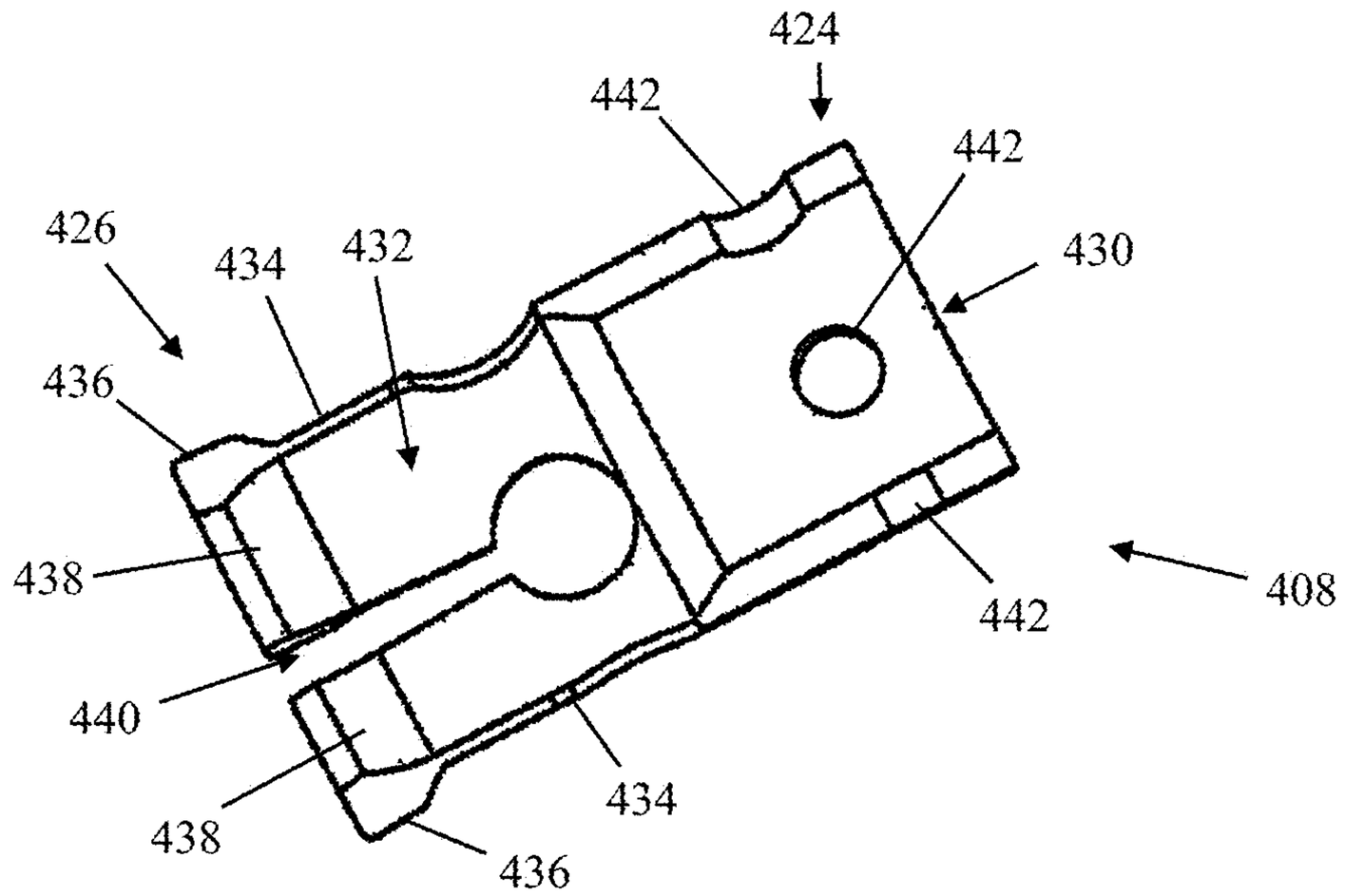

424
442
442
426
434
432
430
436
438
408
442
440
438
434
436

Fig. 70

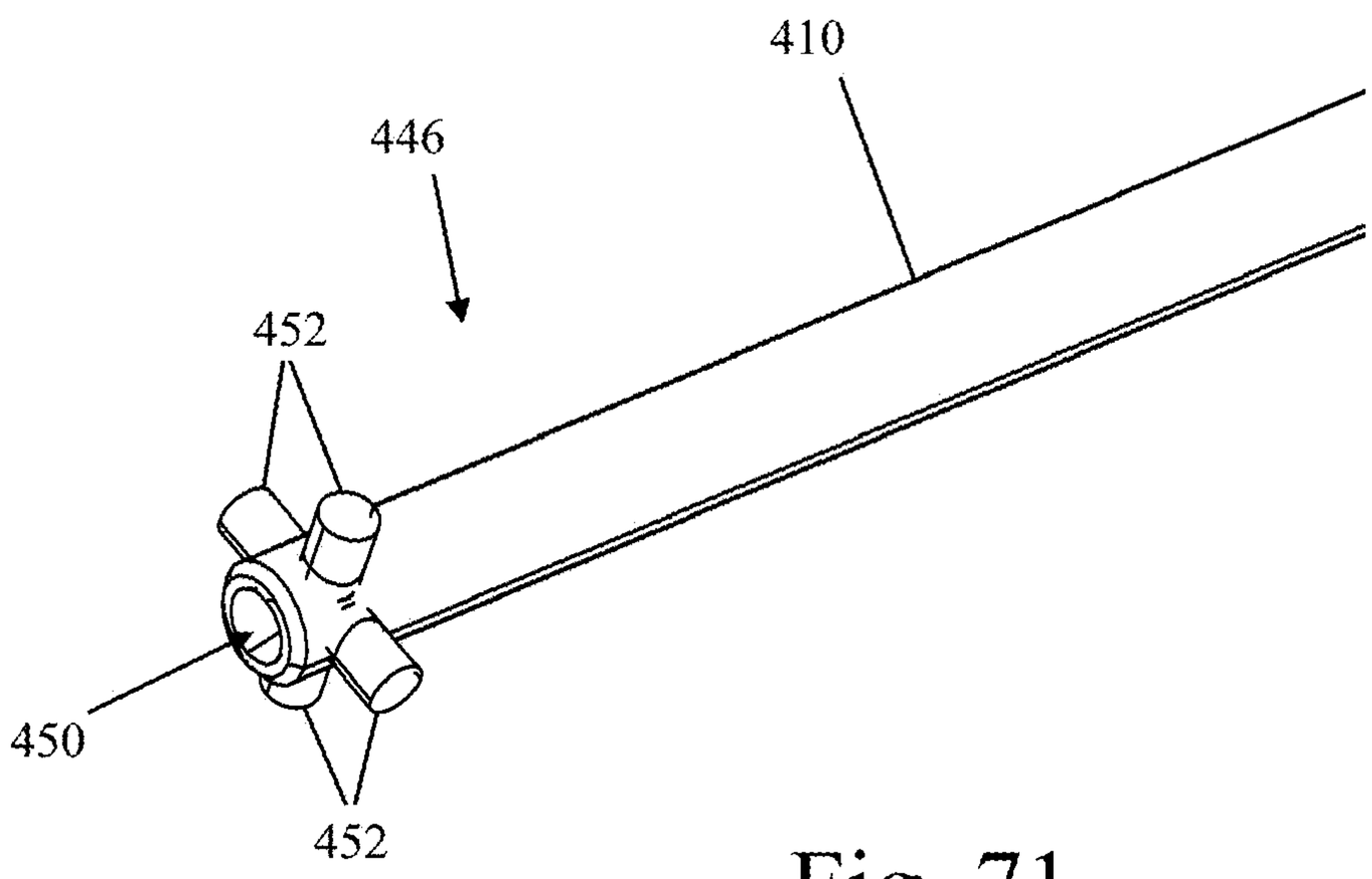

410
446
452
450
452

Fig. 71

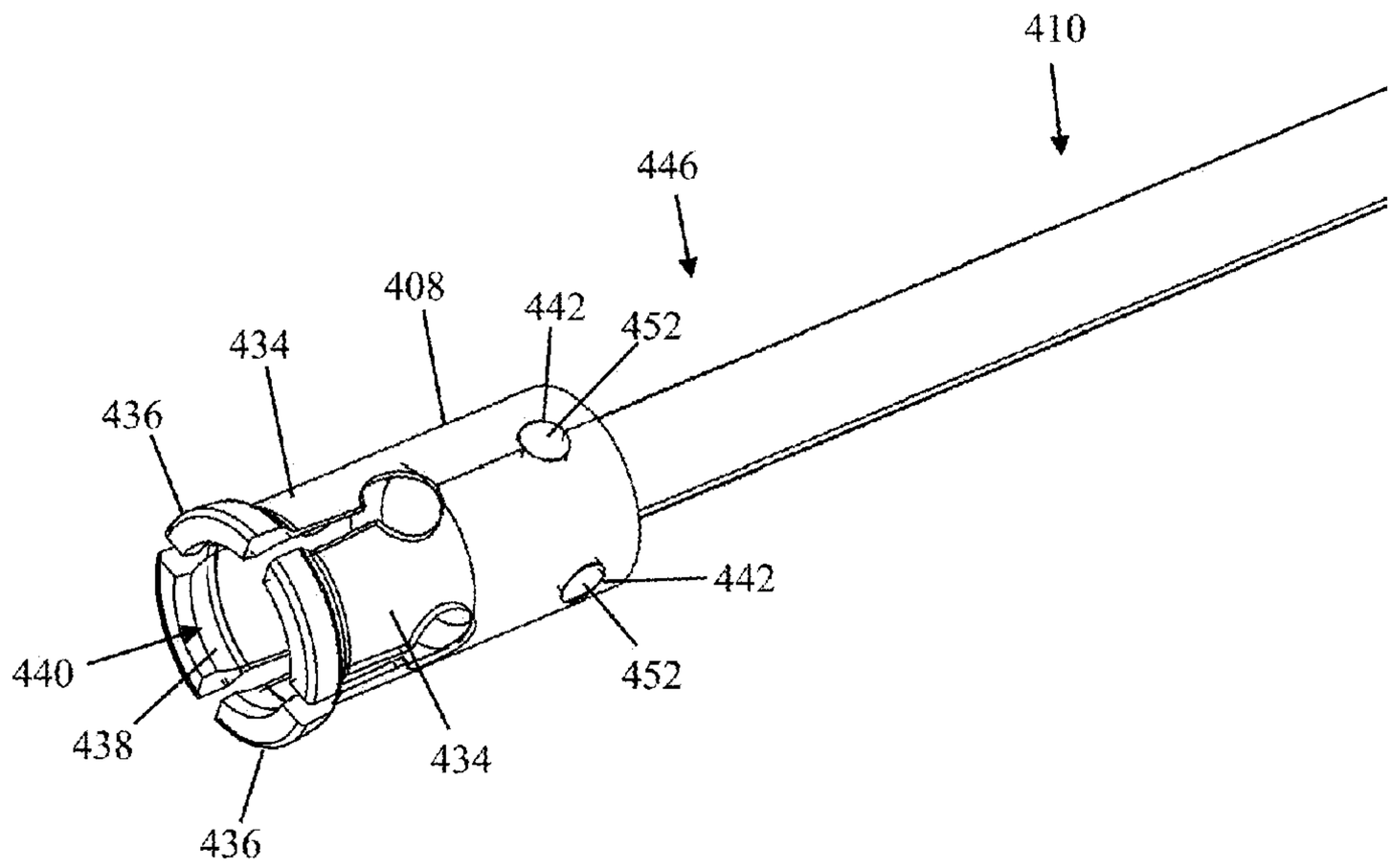

410
446
408
442
452
434
436
442
440
452
438
434
436

Fig. 72

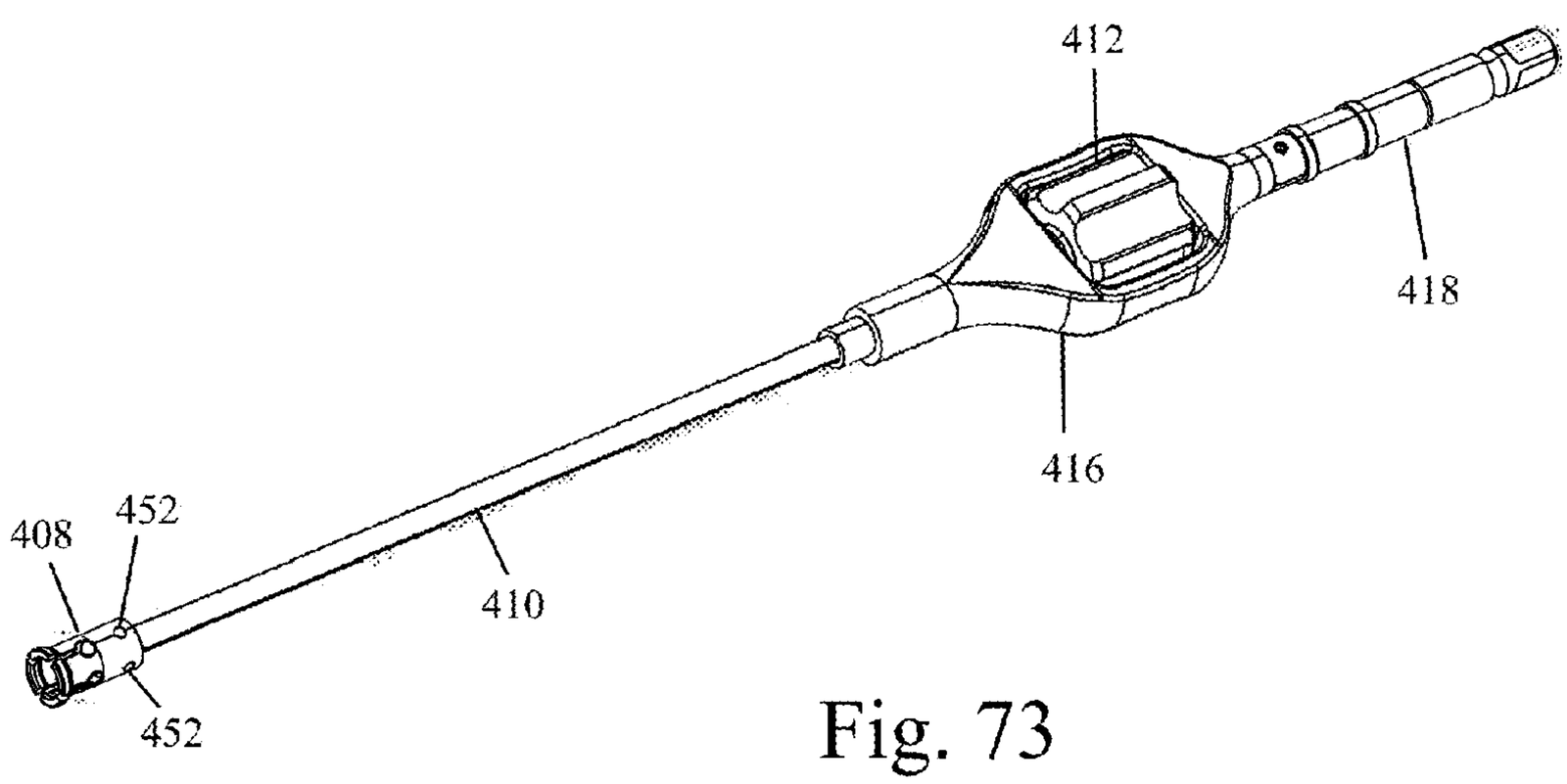

412
418
416
408
452
410
452

Fig. 73

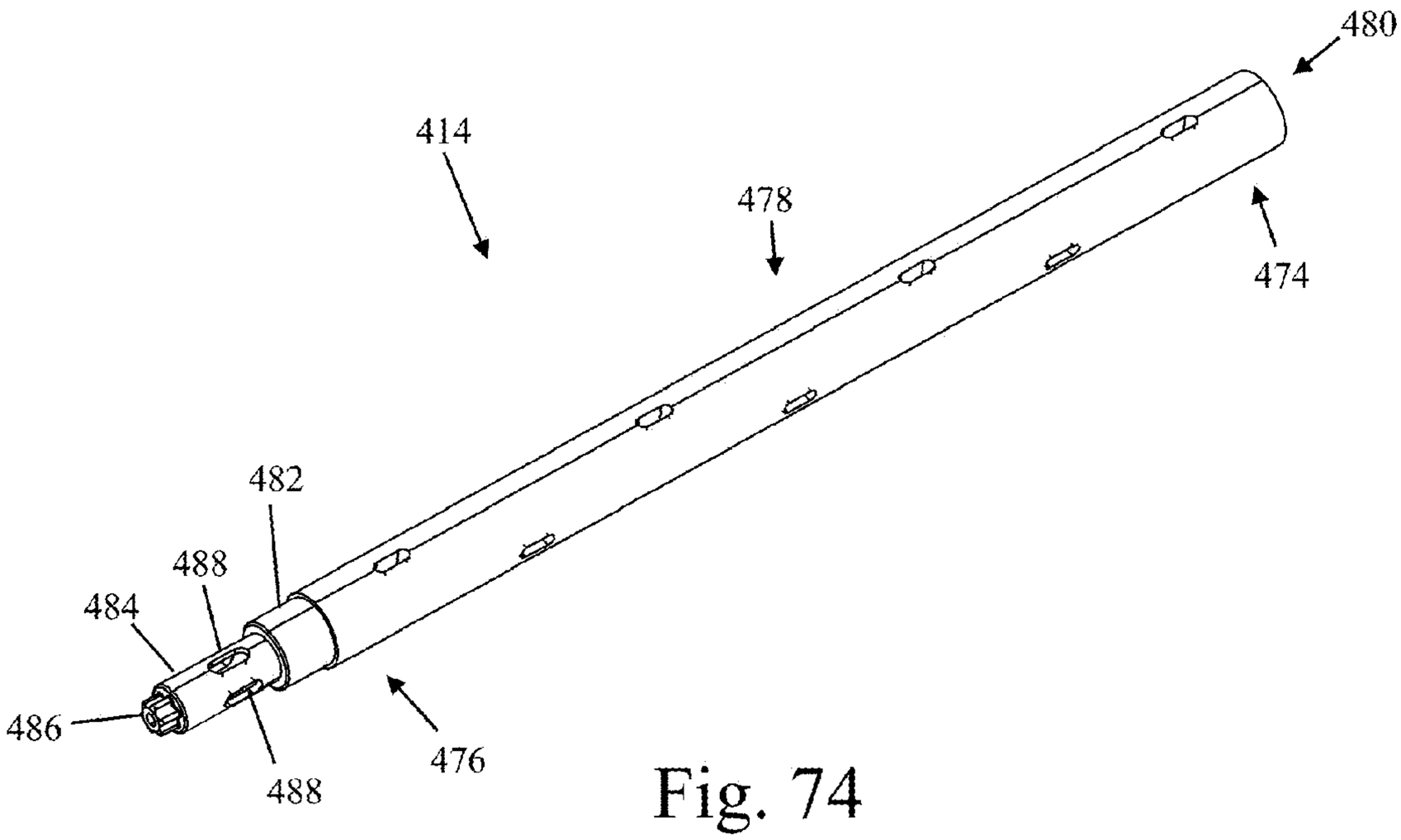

480
414
478
474
482
488
484
486
488
476

Fig. 74

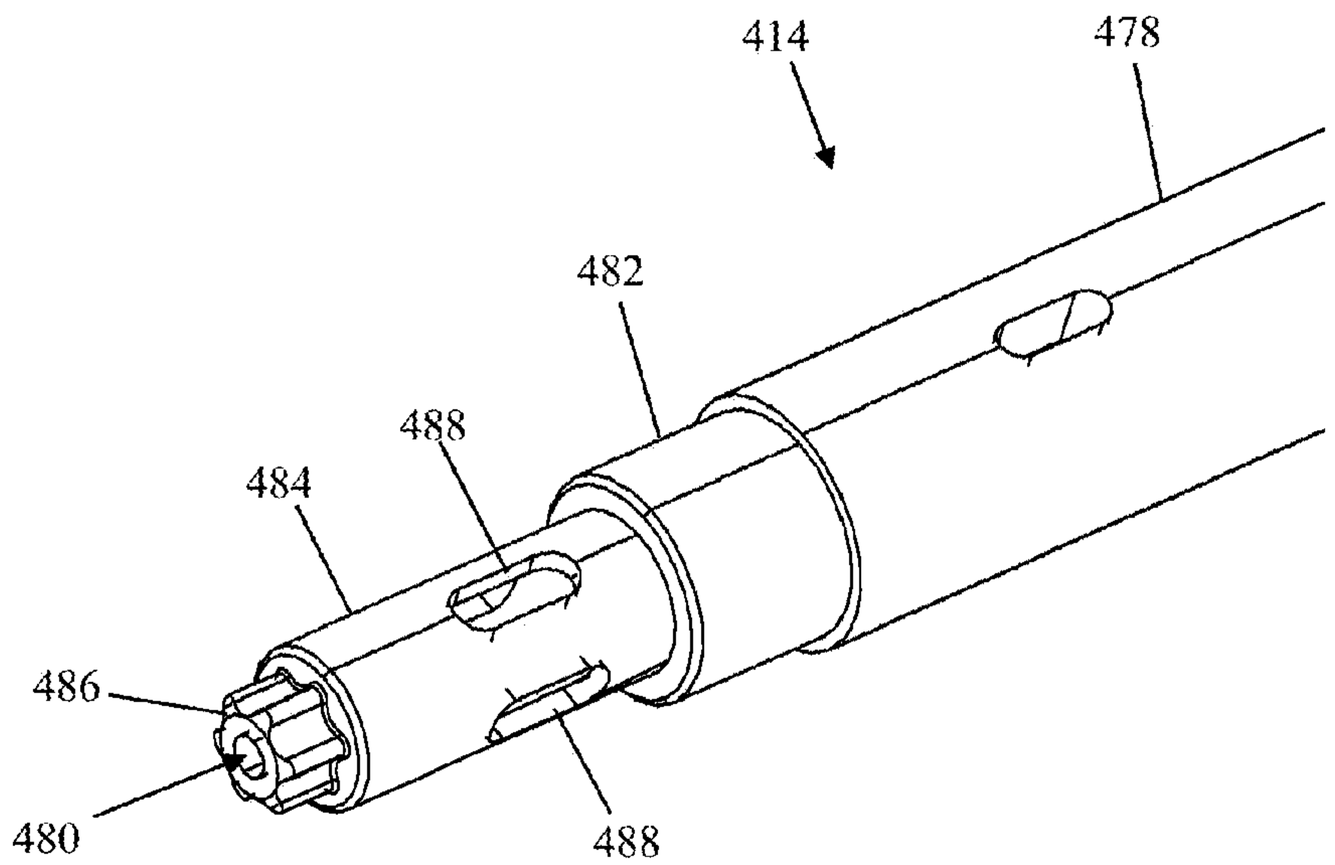

414
478
482
488
484
486
480
488

Fig. 75

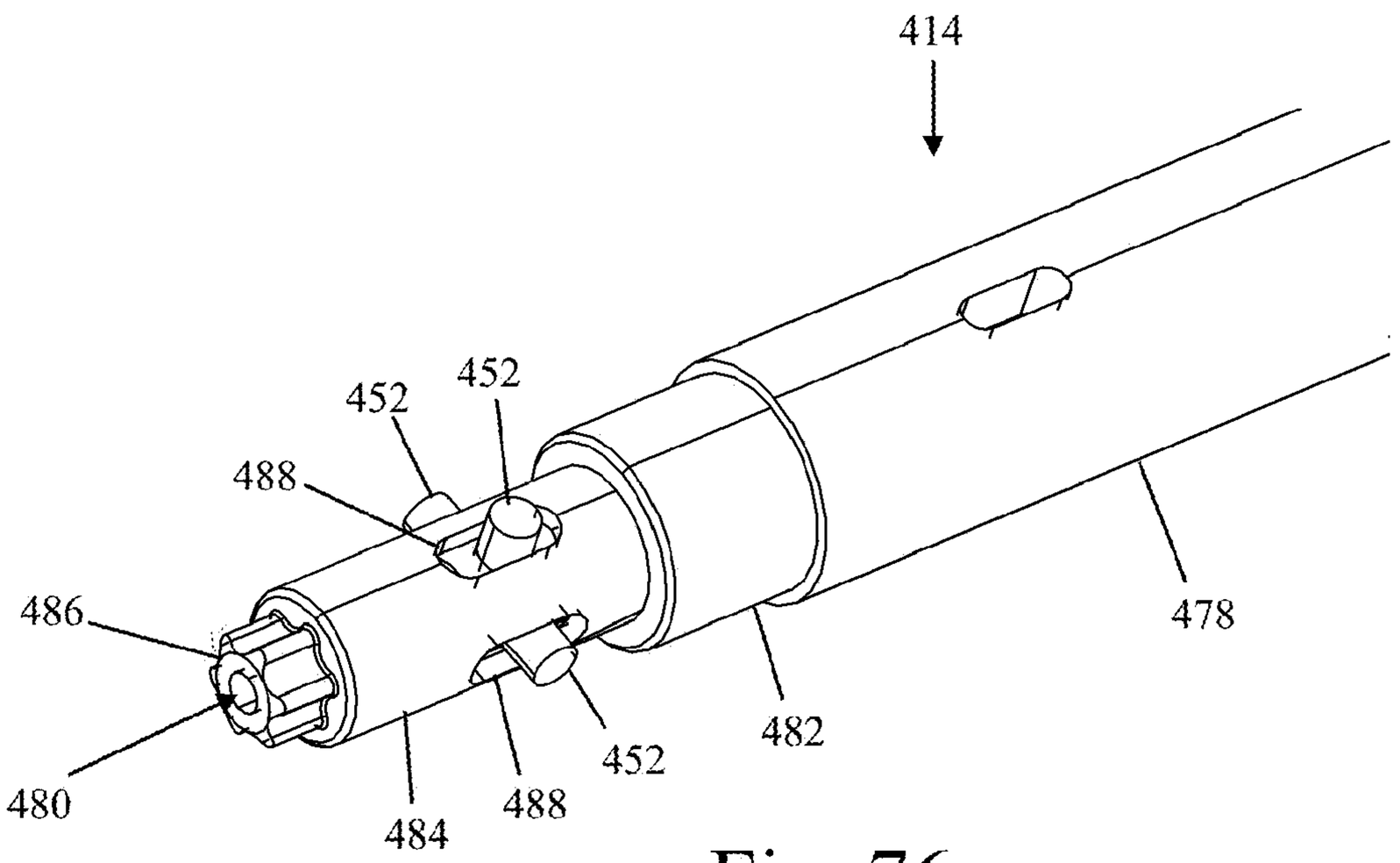

414
452
452
488
486
480
484
488
452
482
478

Fig. 76

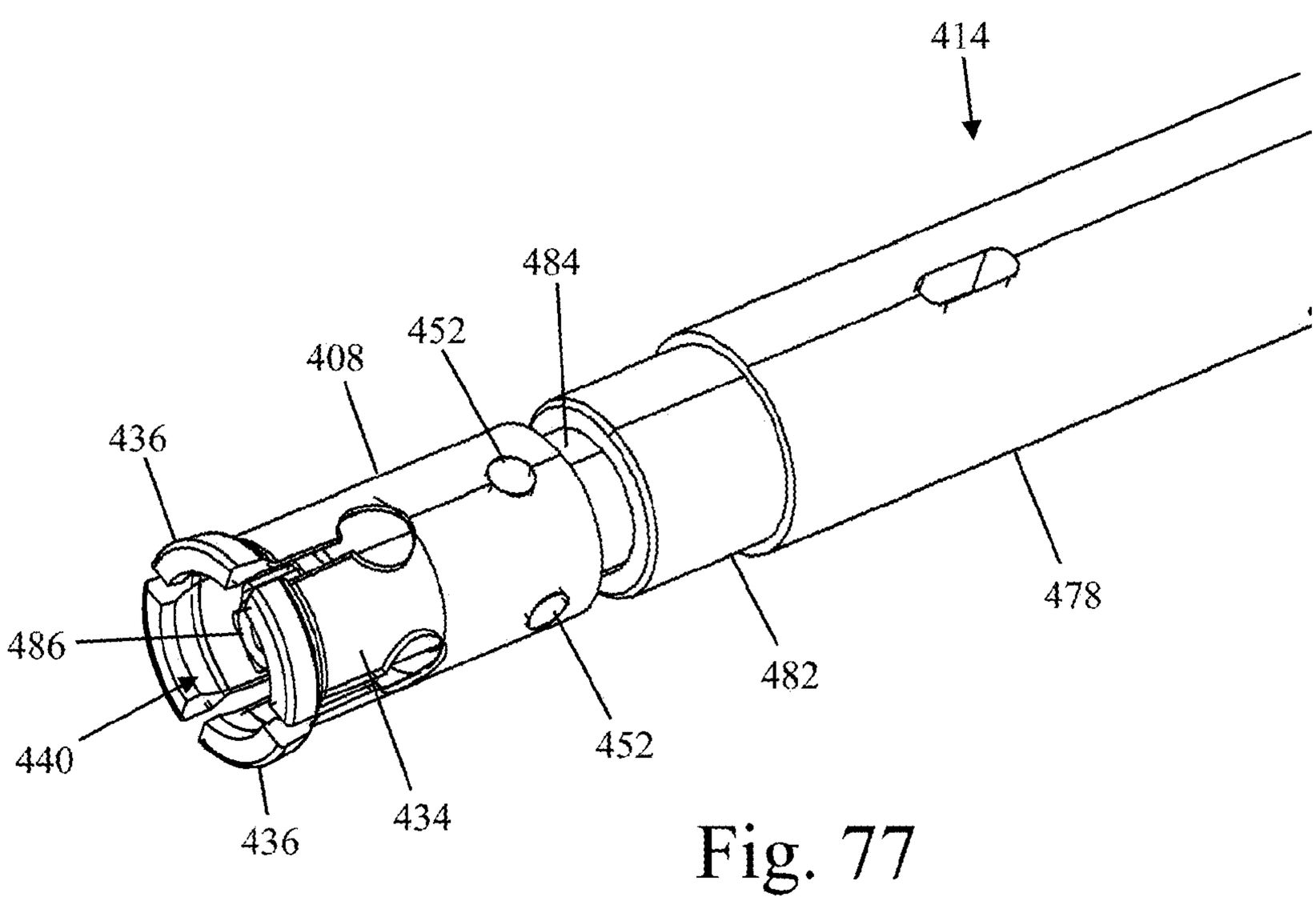

414
484
452
408
436
486
440
436
434
452
482
478

Fig. 77

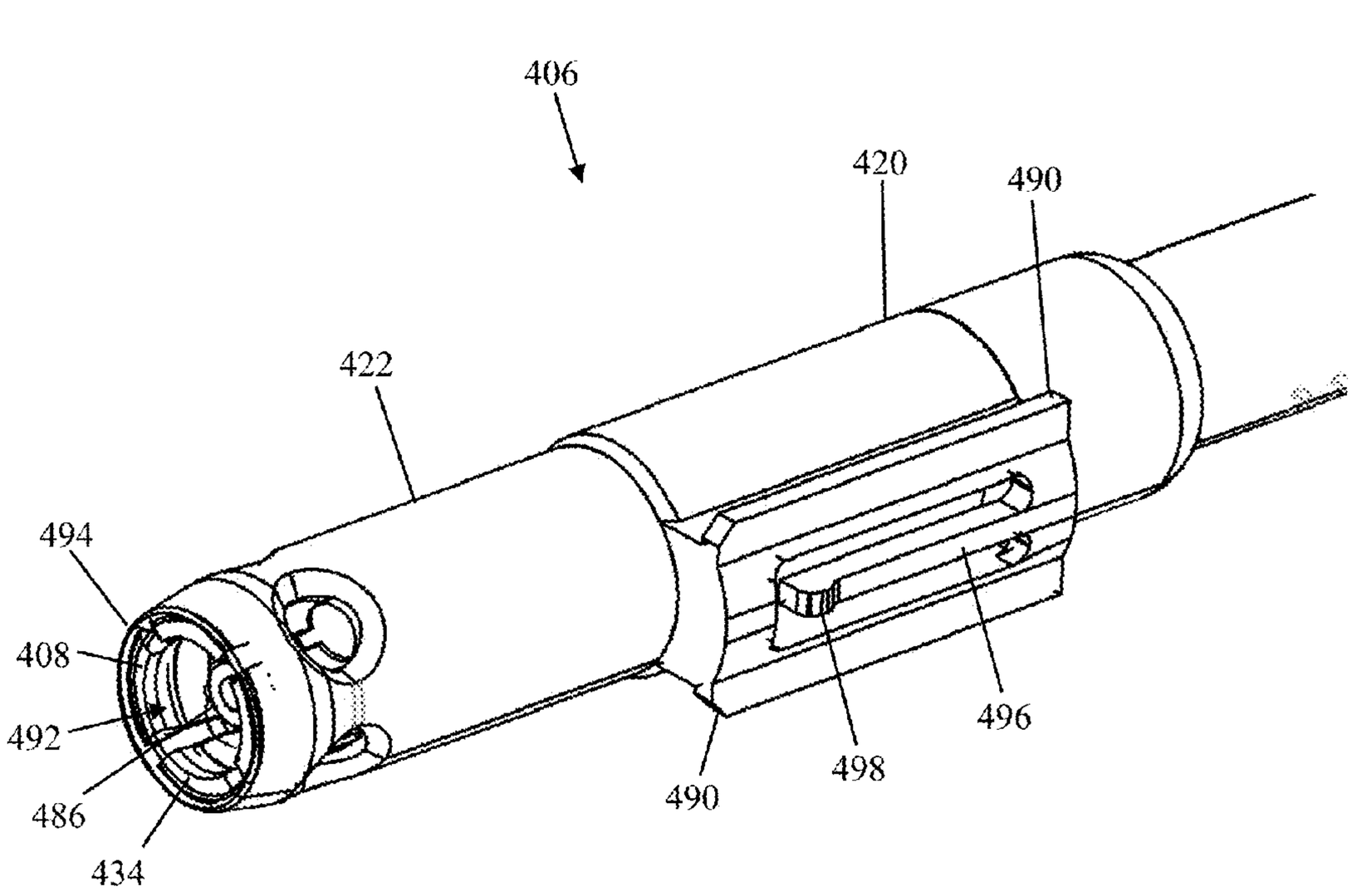


Fig. 78

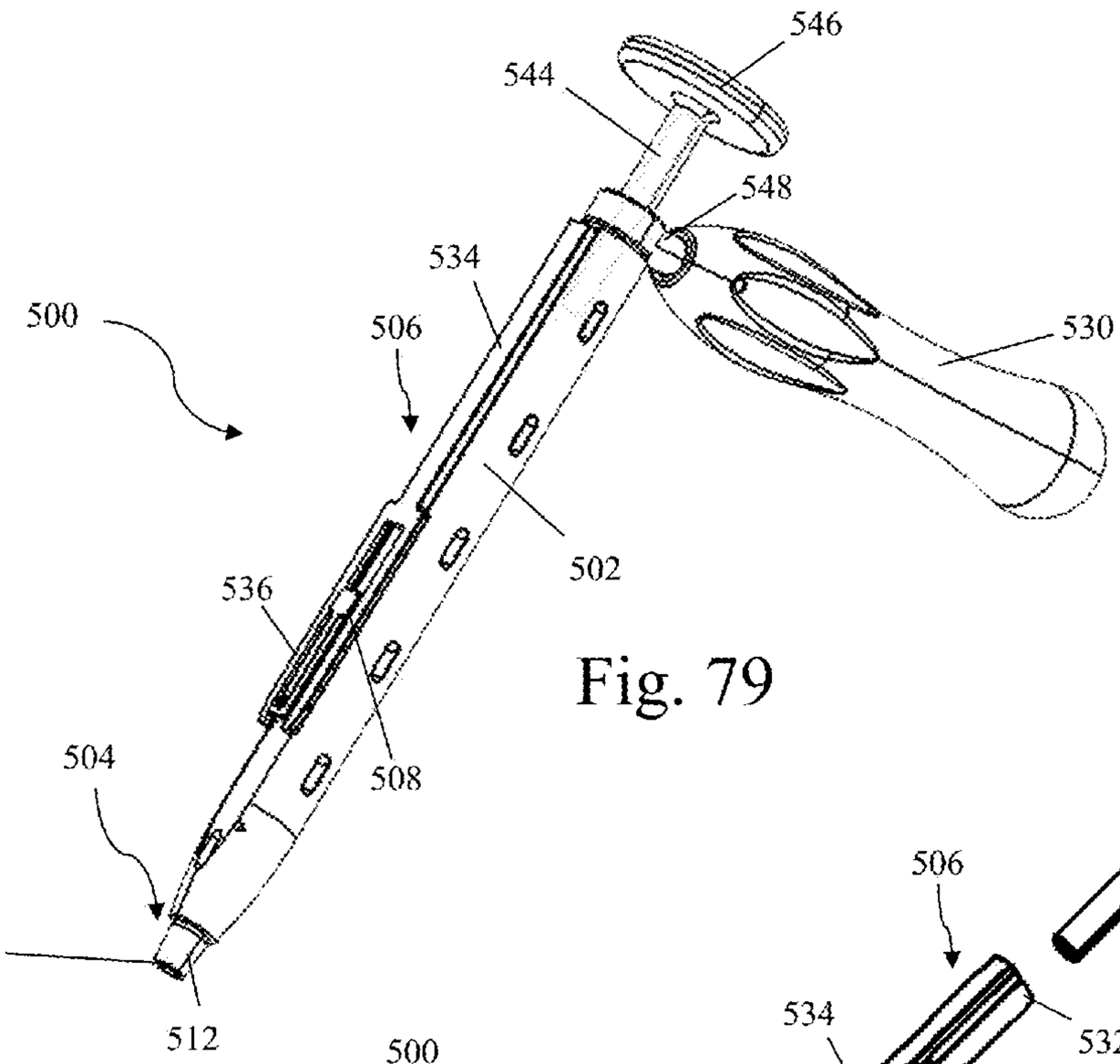

546
544
548
534
500
506
530
502
536
508
504
514
512

Fig. 79

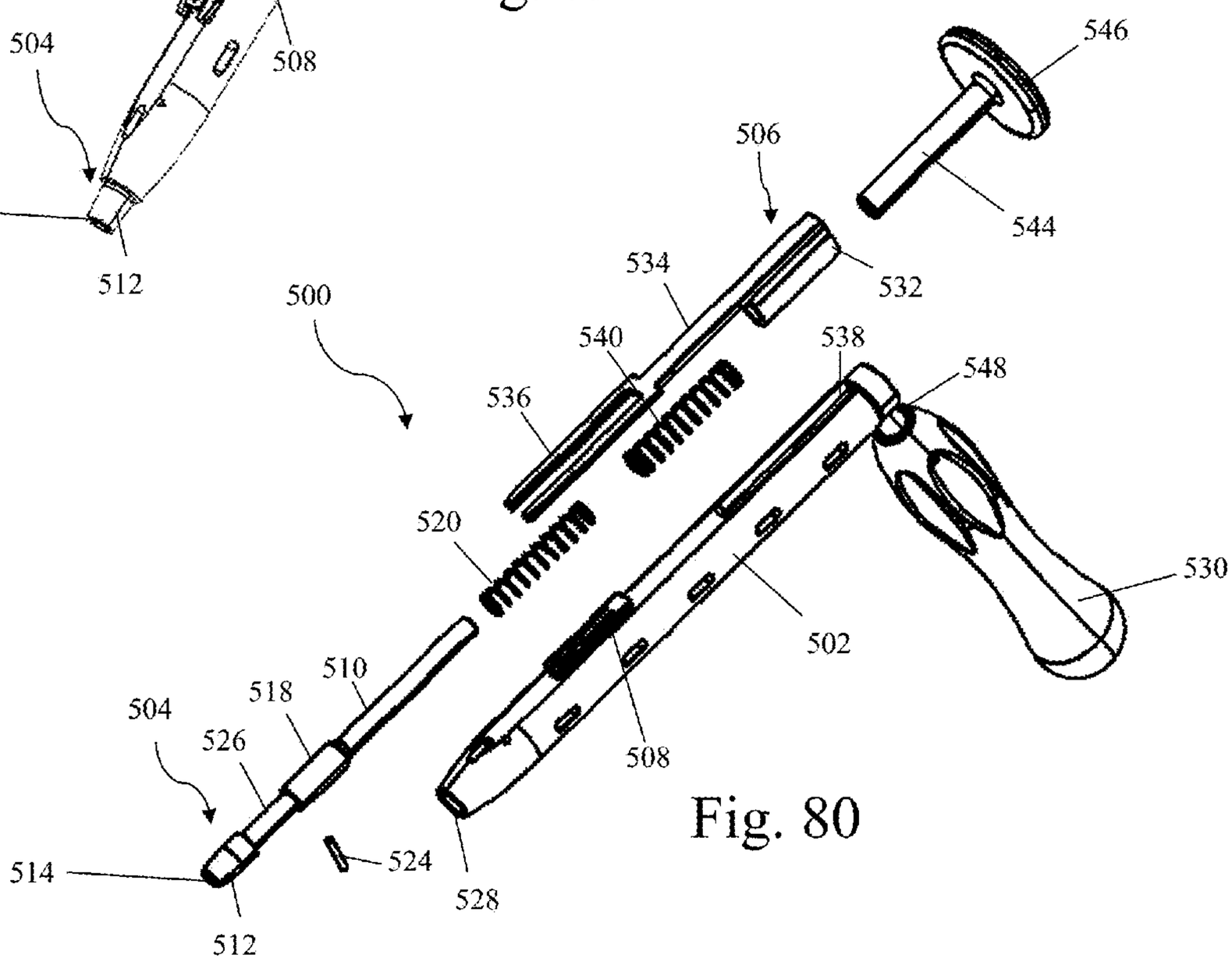

546
506
544
534
532
500
540
538
548
536
520
530
502
510
518
504
526
508
514
524
528
512

Fig. 80

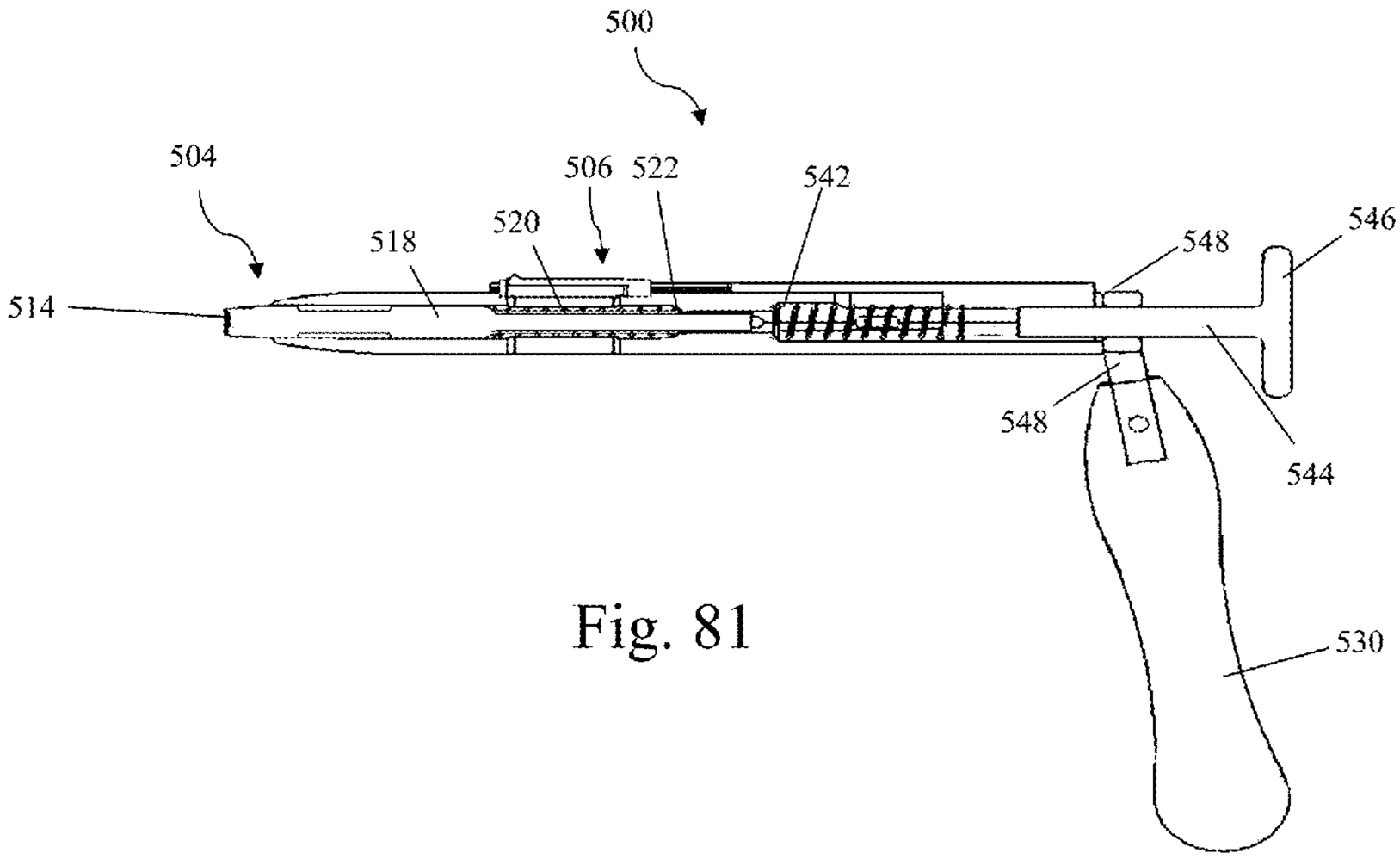

500
504
506
522
542
518
520
546
548
514
548
544
530

Fig. 81

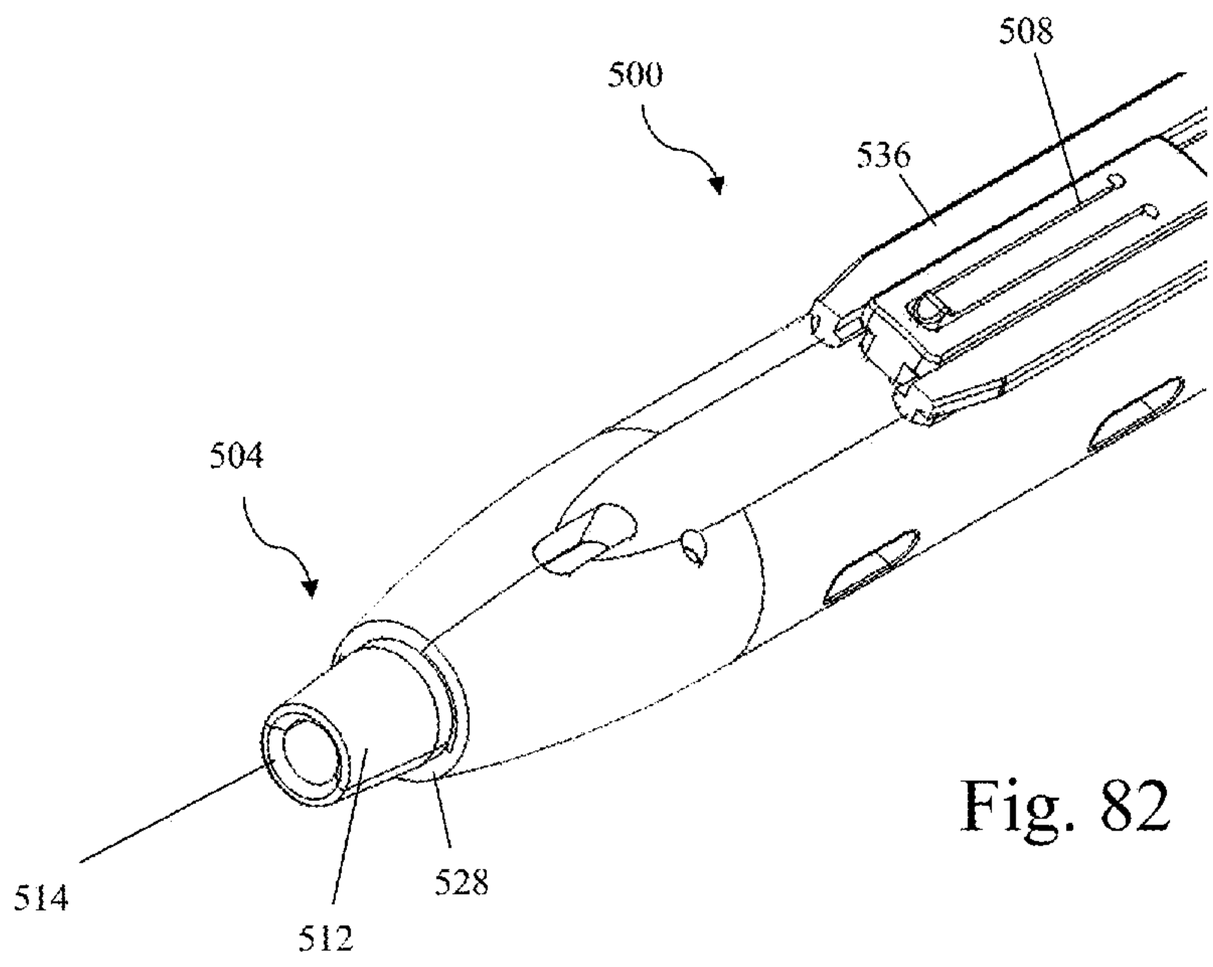

508
500
536
504
514
512
528

Fig. 82

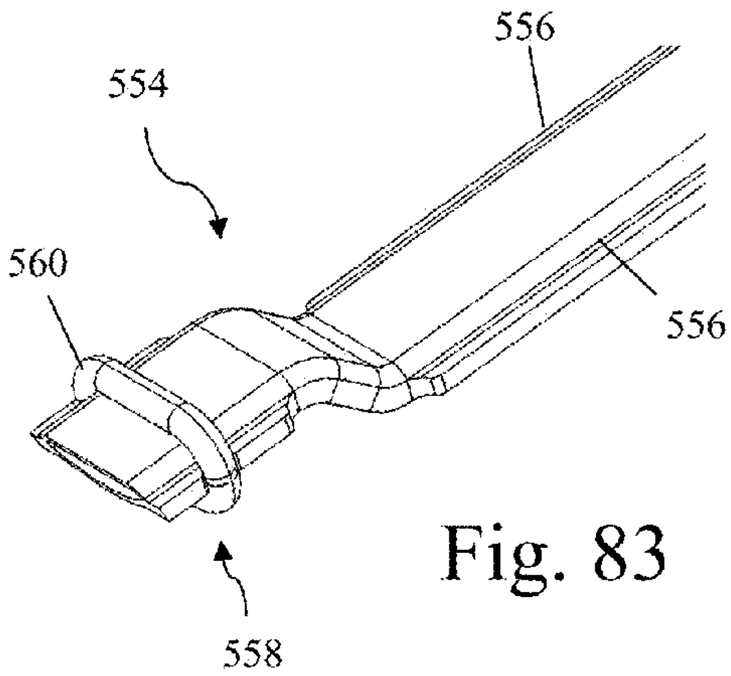


Fig. 83

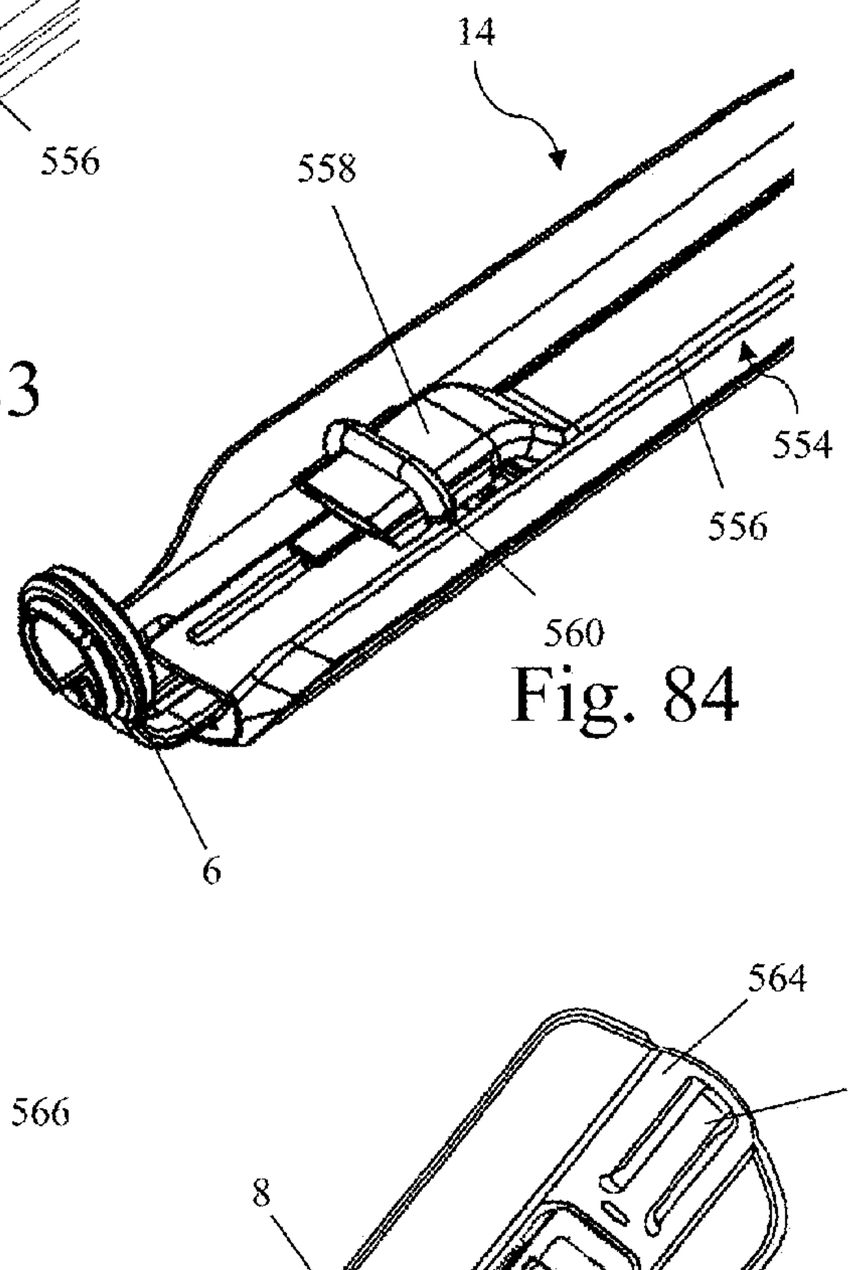


Fig. 84

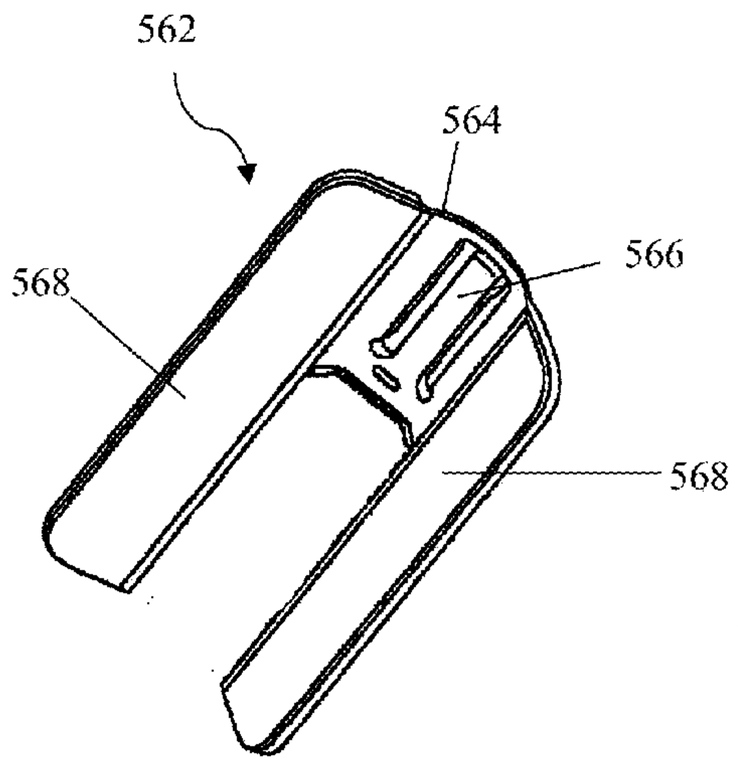


Fig. 85

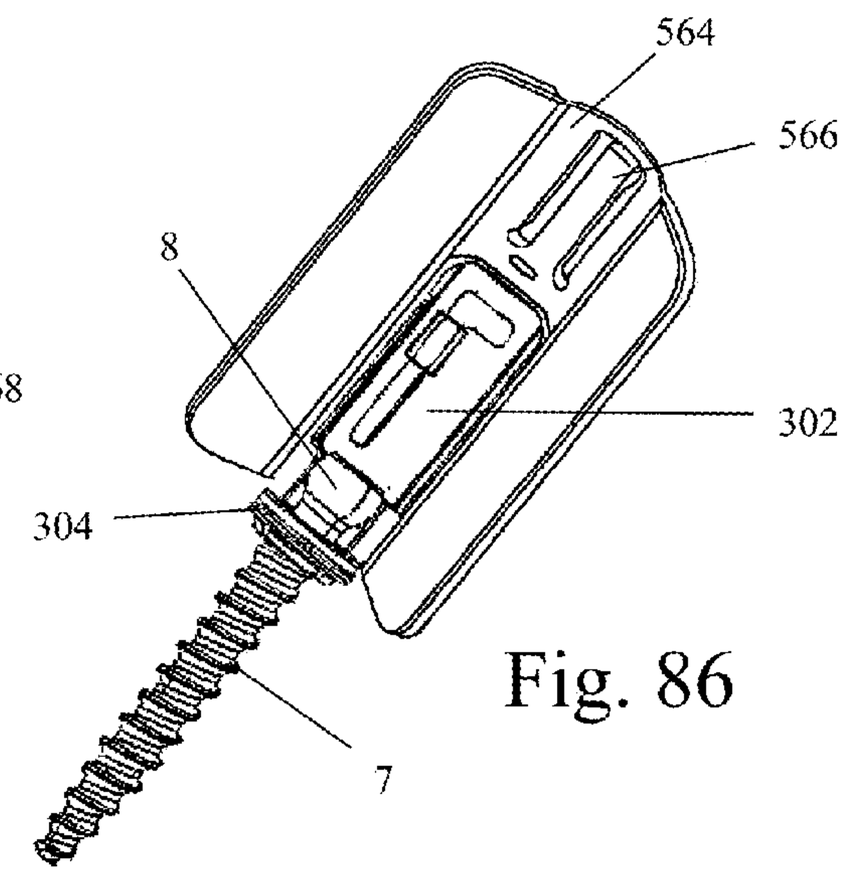


Fig. 86

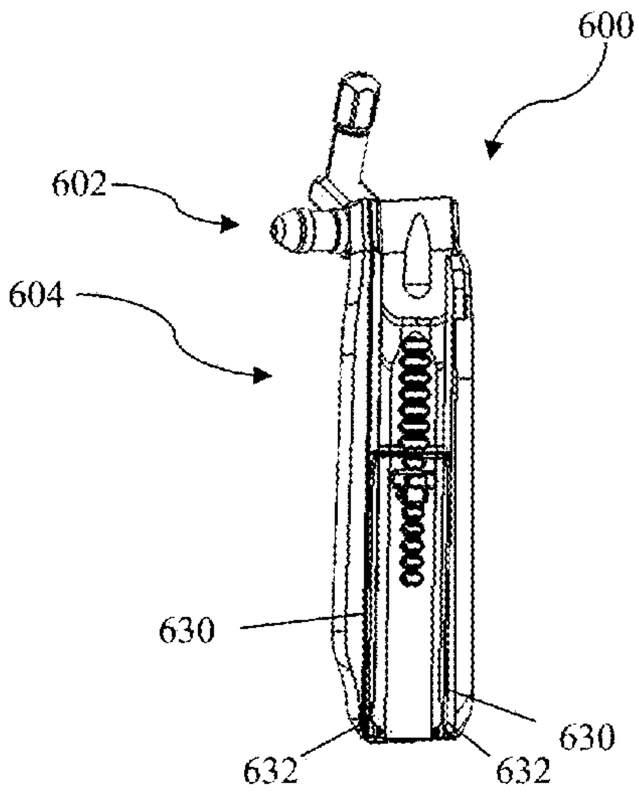


Fig. 87

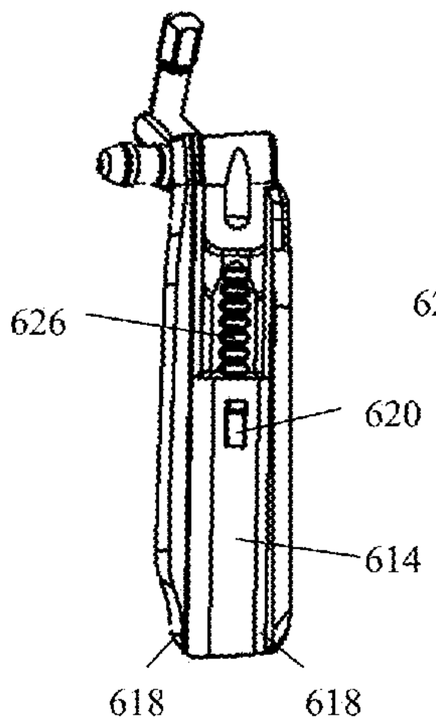


Fig. 88

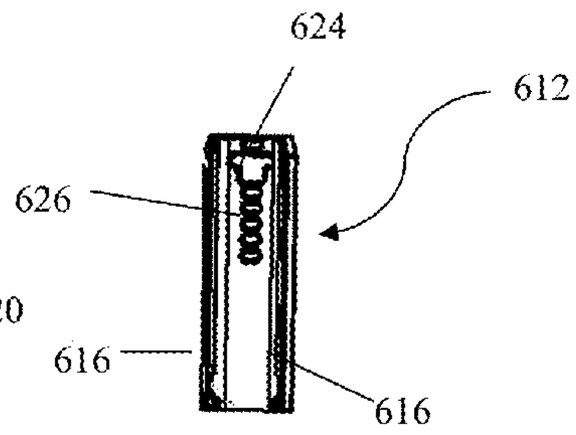


Fig. 89

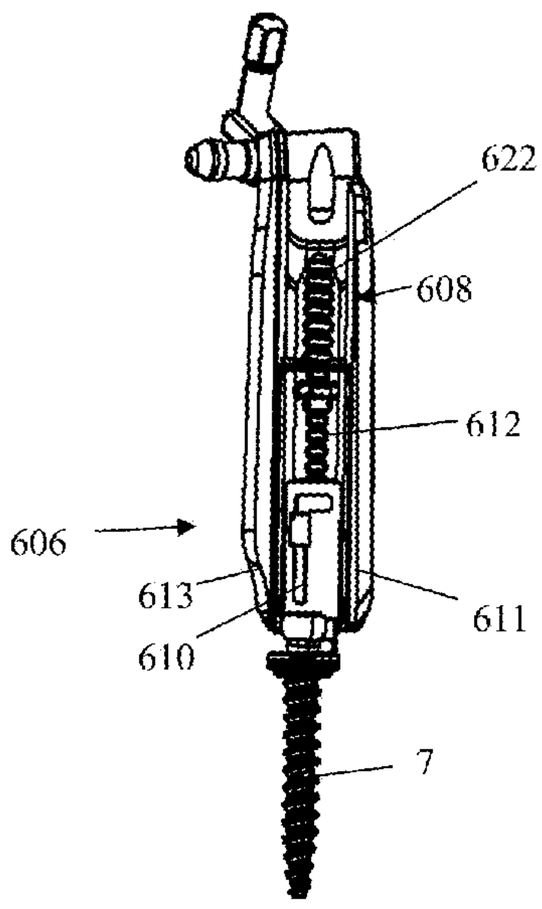


Fig. 90

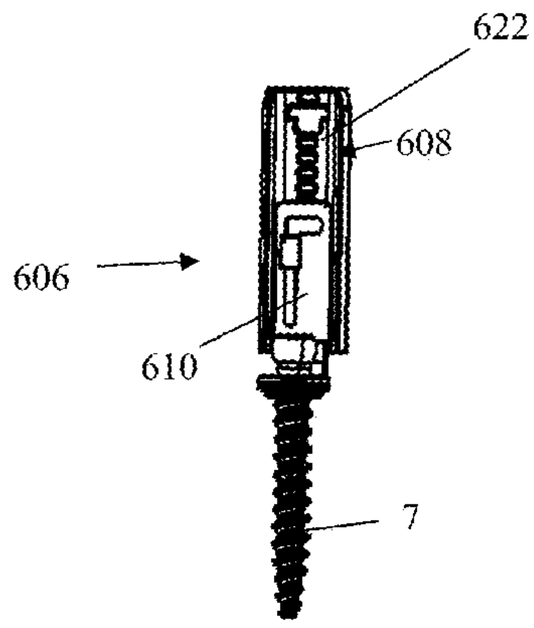


Fig. 91

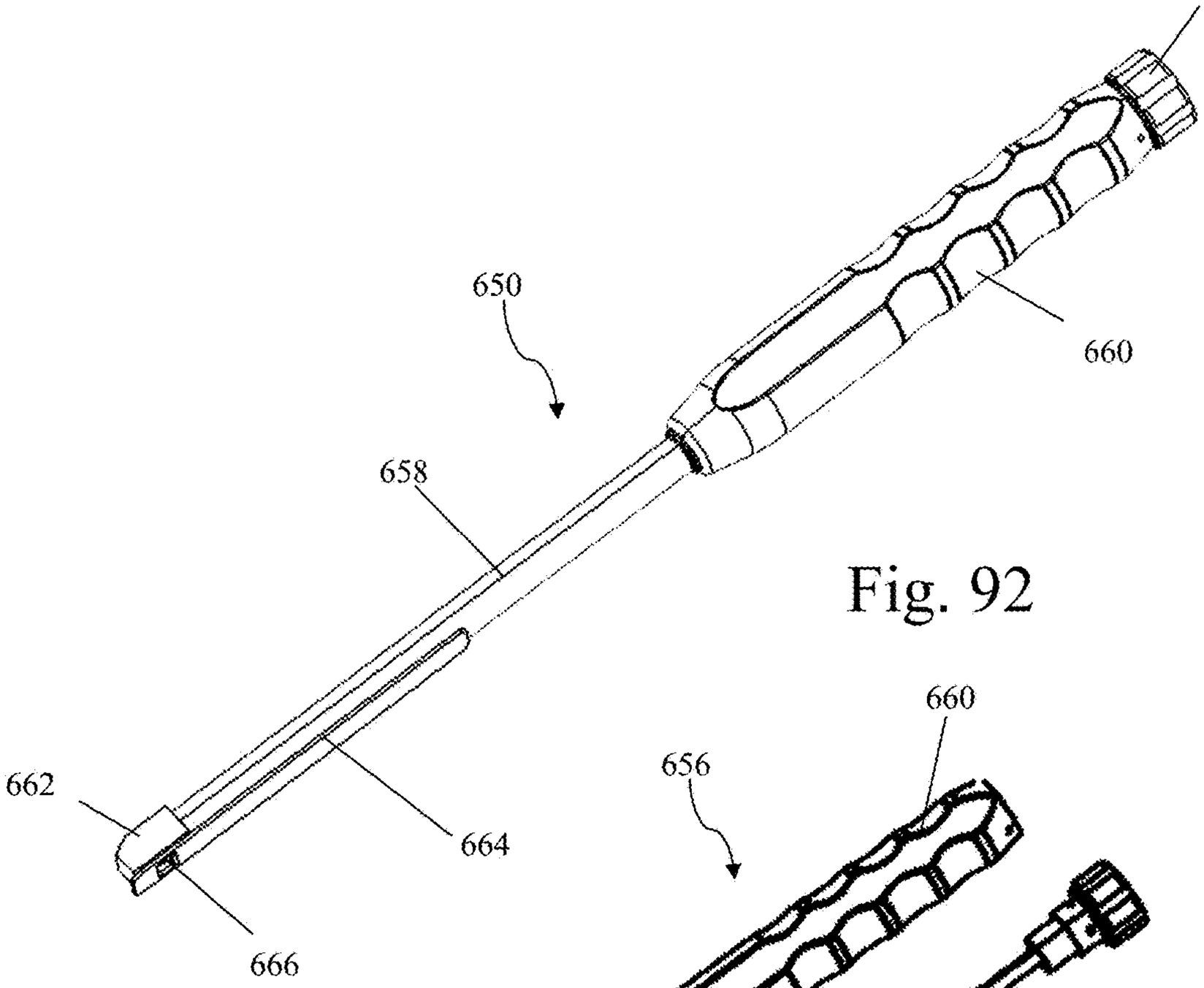


Fig. 92

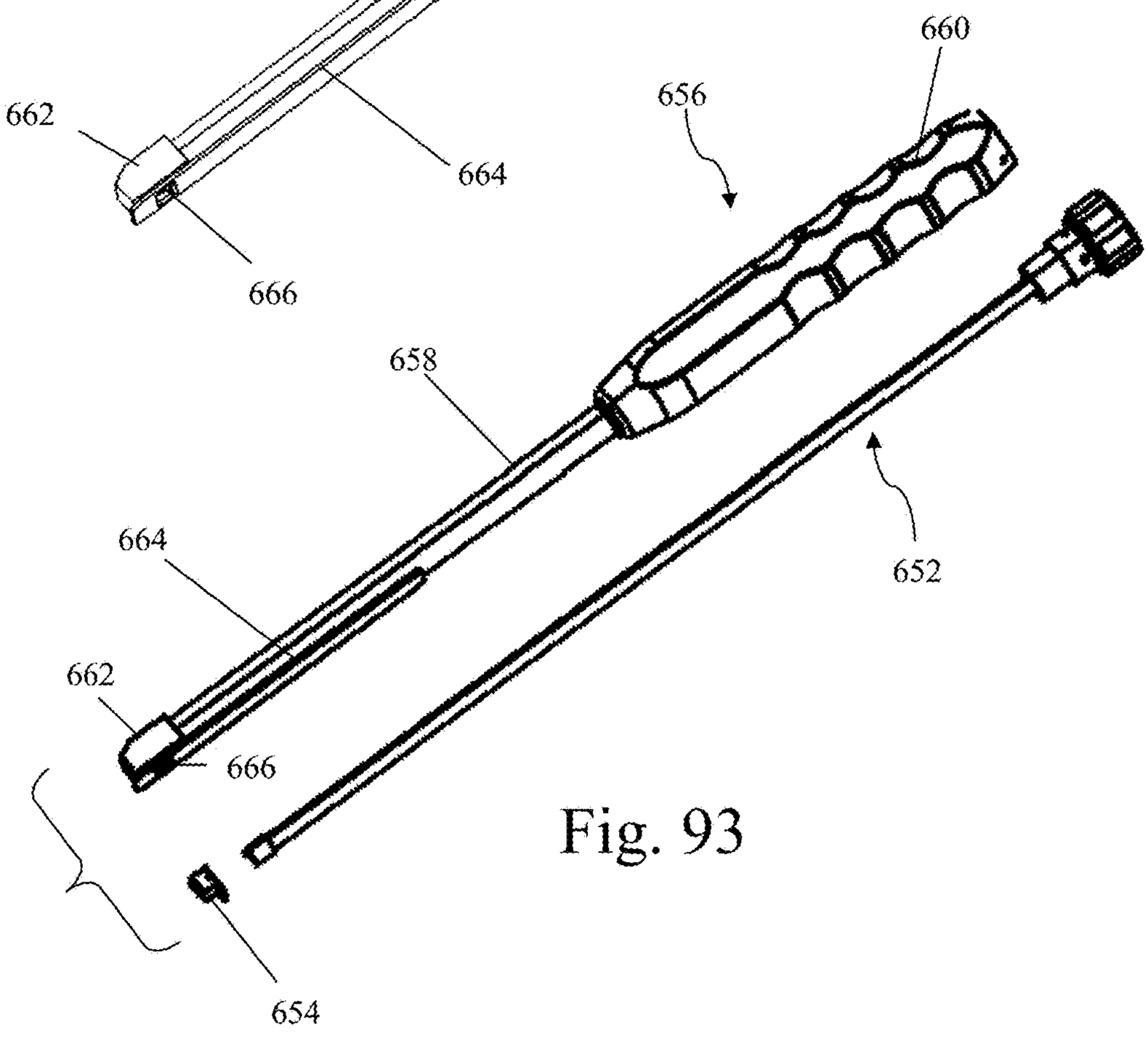


Fig. 93

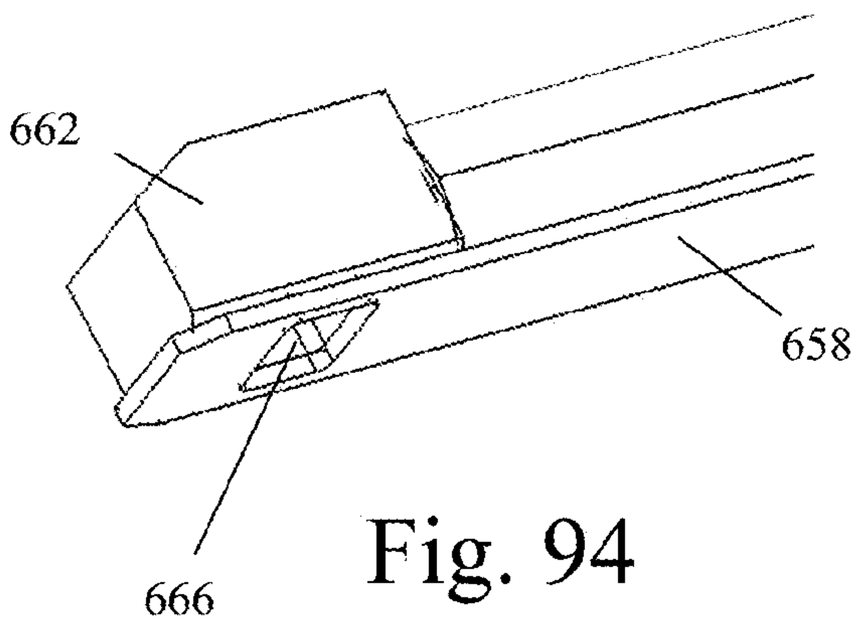


Fig. 94

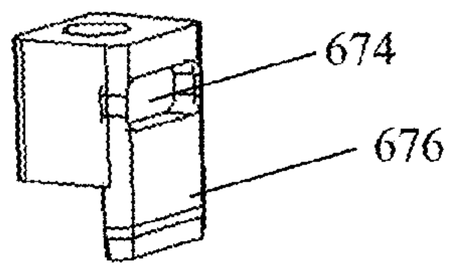


Fig. 95

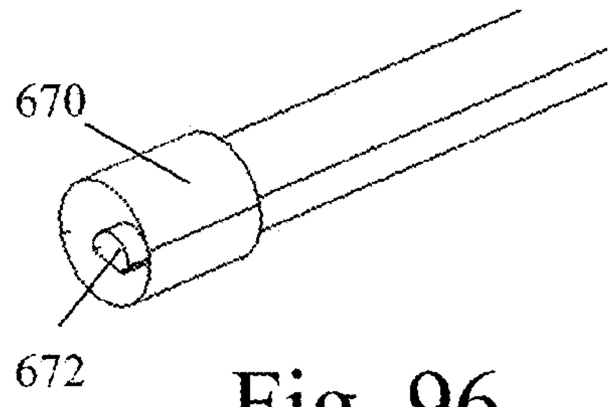


Fig. 96

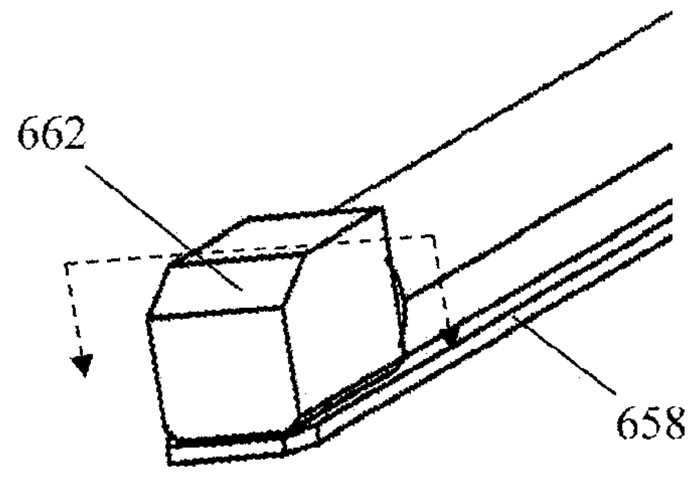


Fig. 97

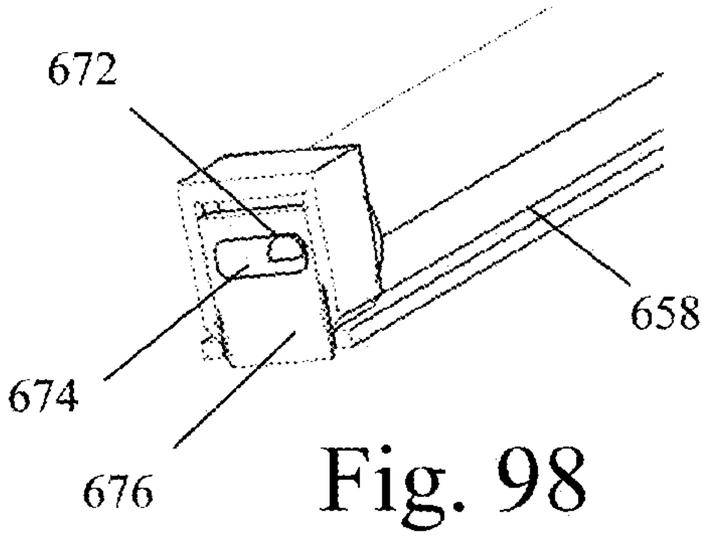


Fig. 98

Fig. 99

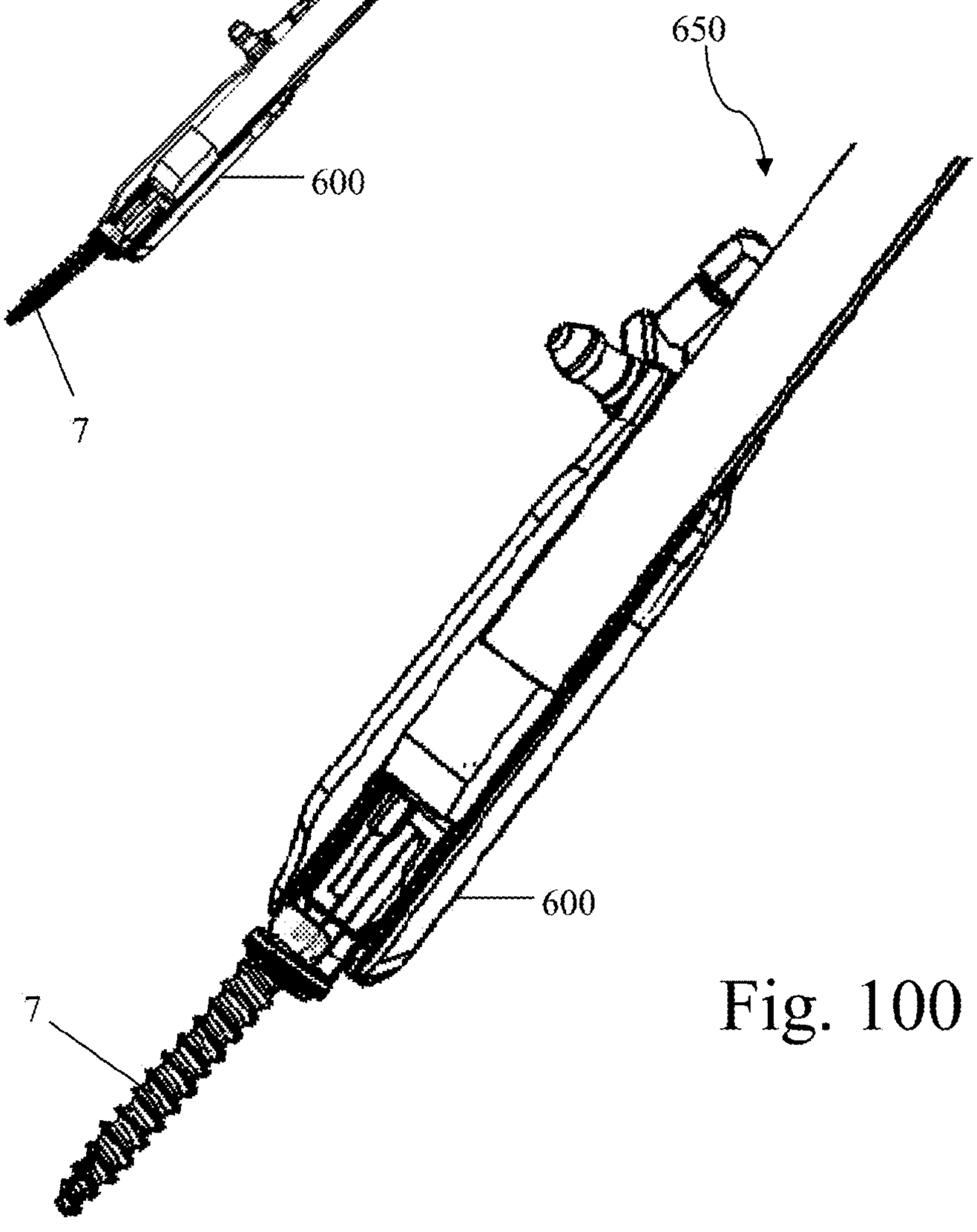


Fig. 100

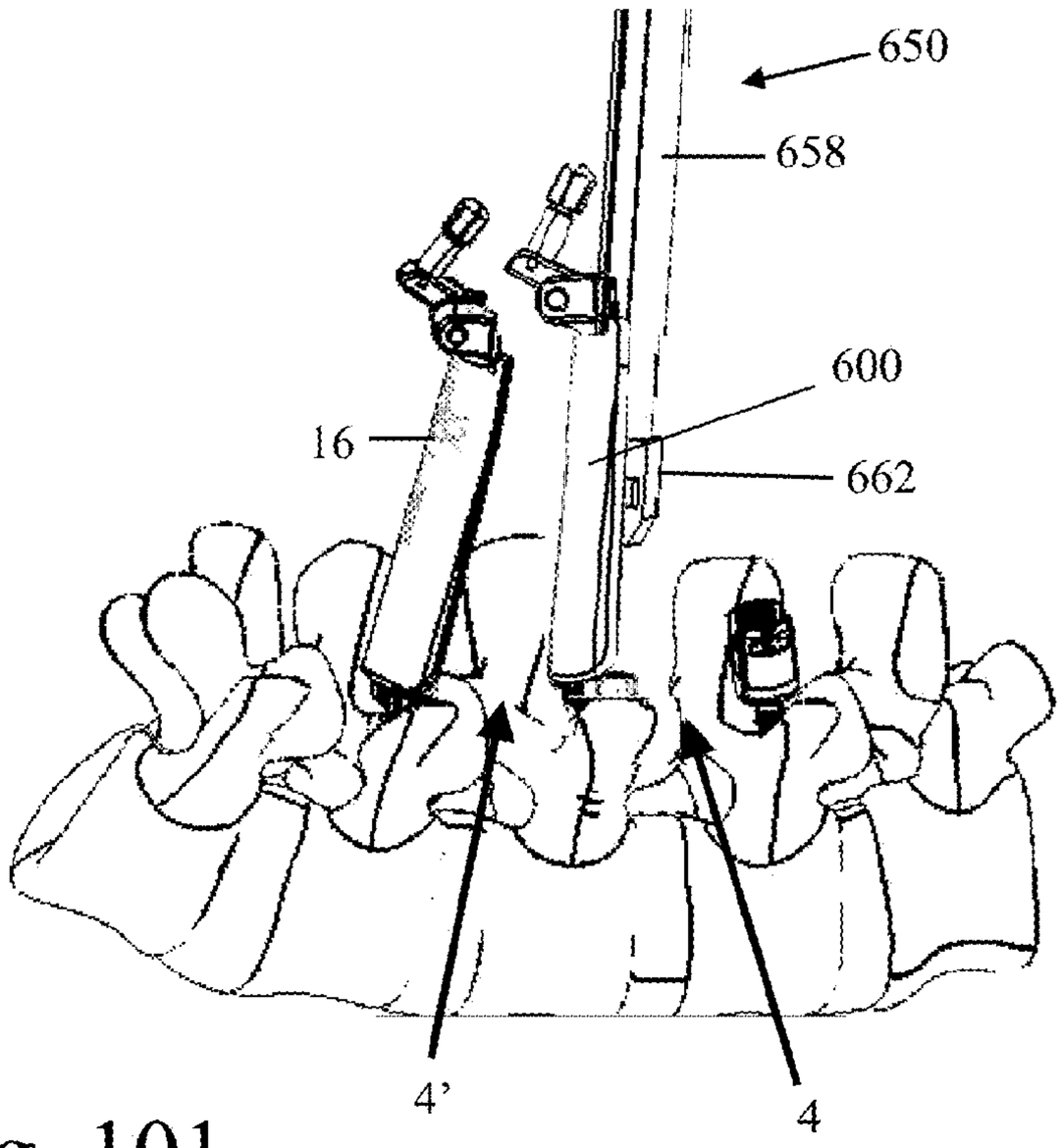


Fig. 101

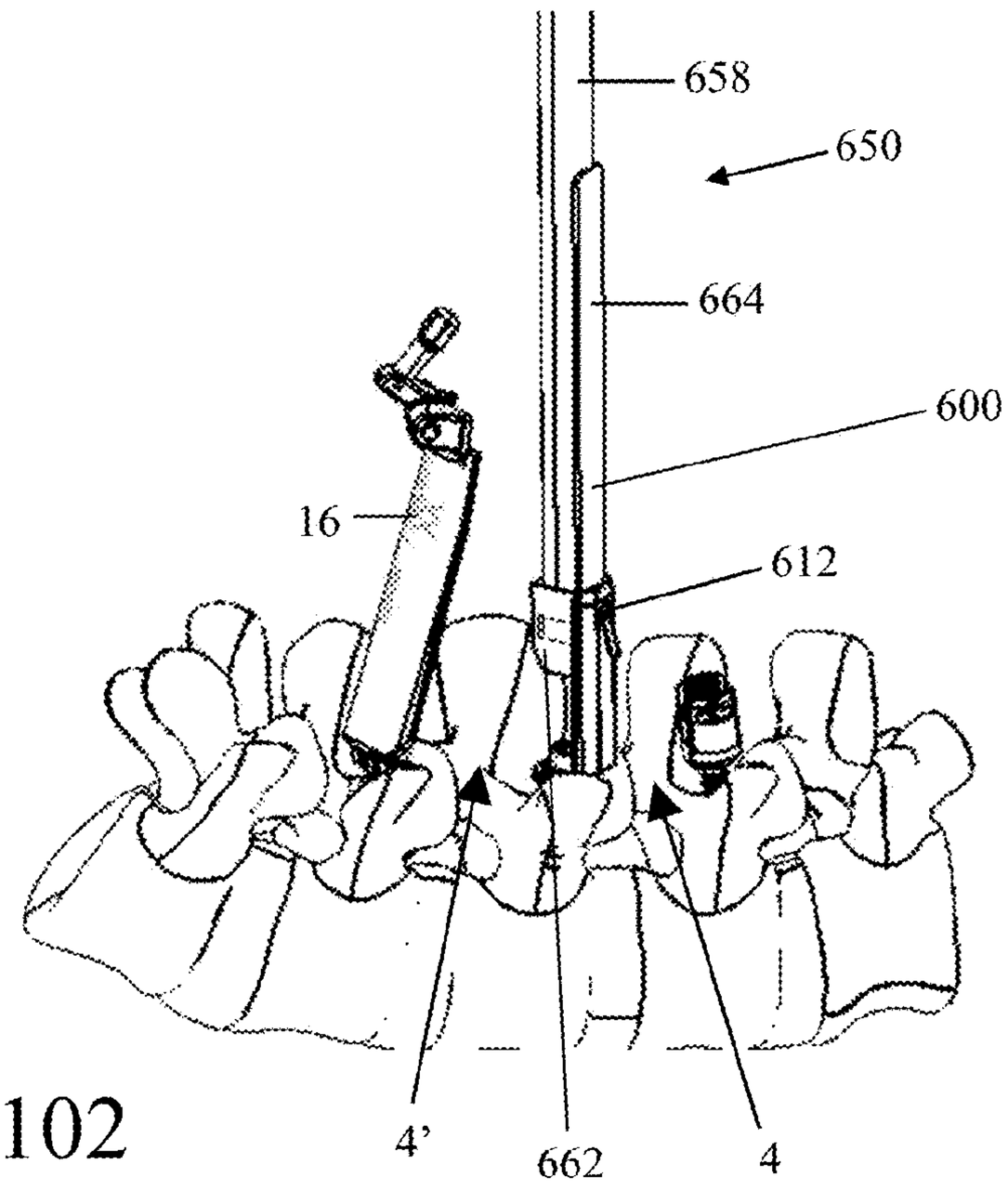


Fig. 102

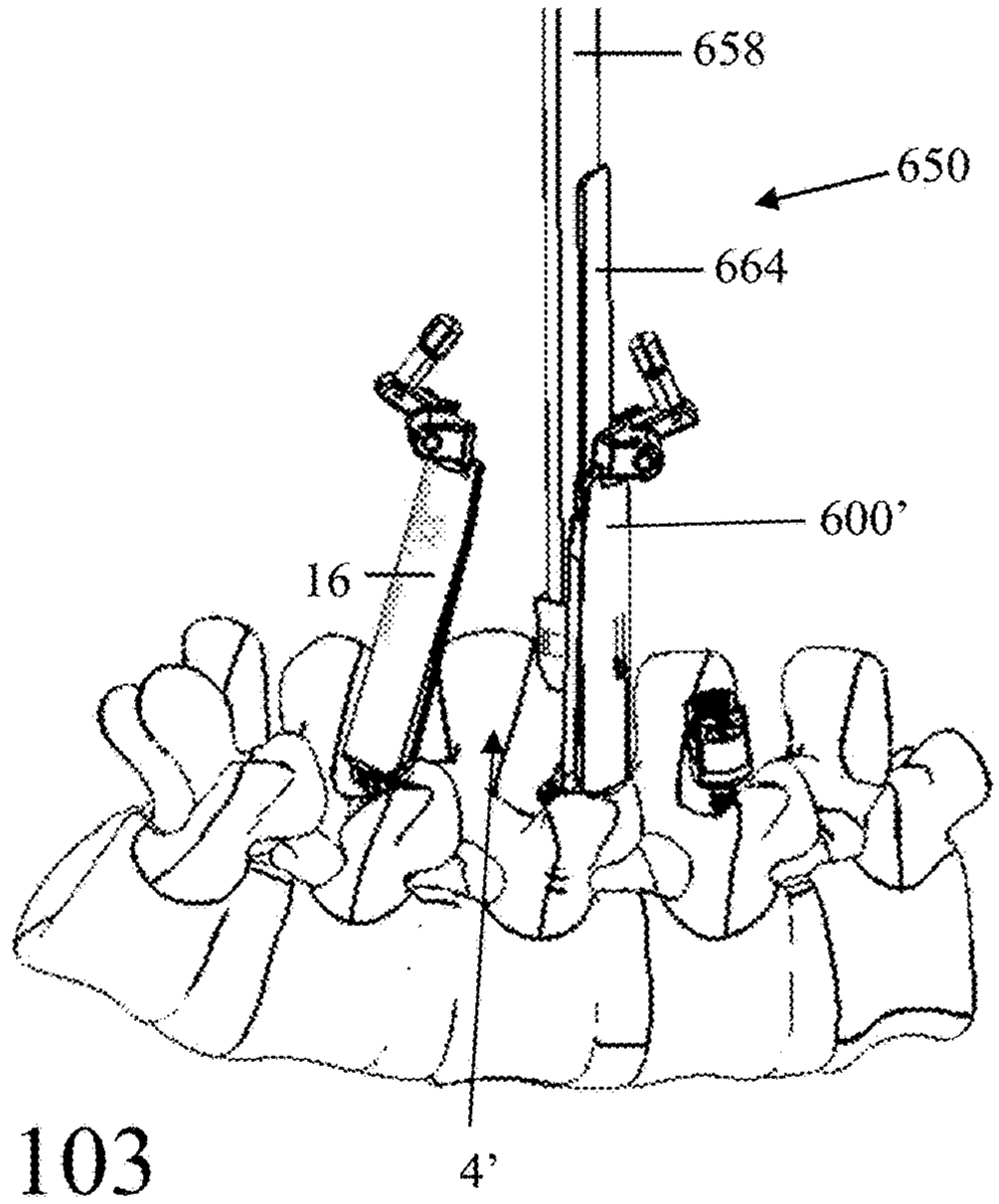


Fig. 103

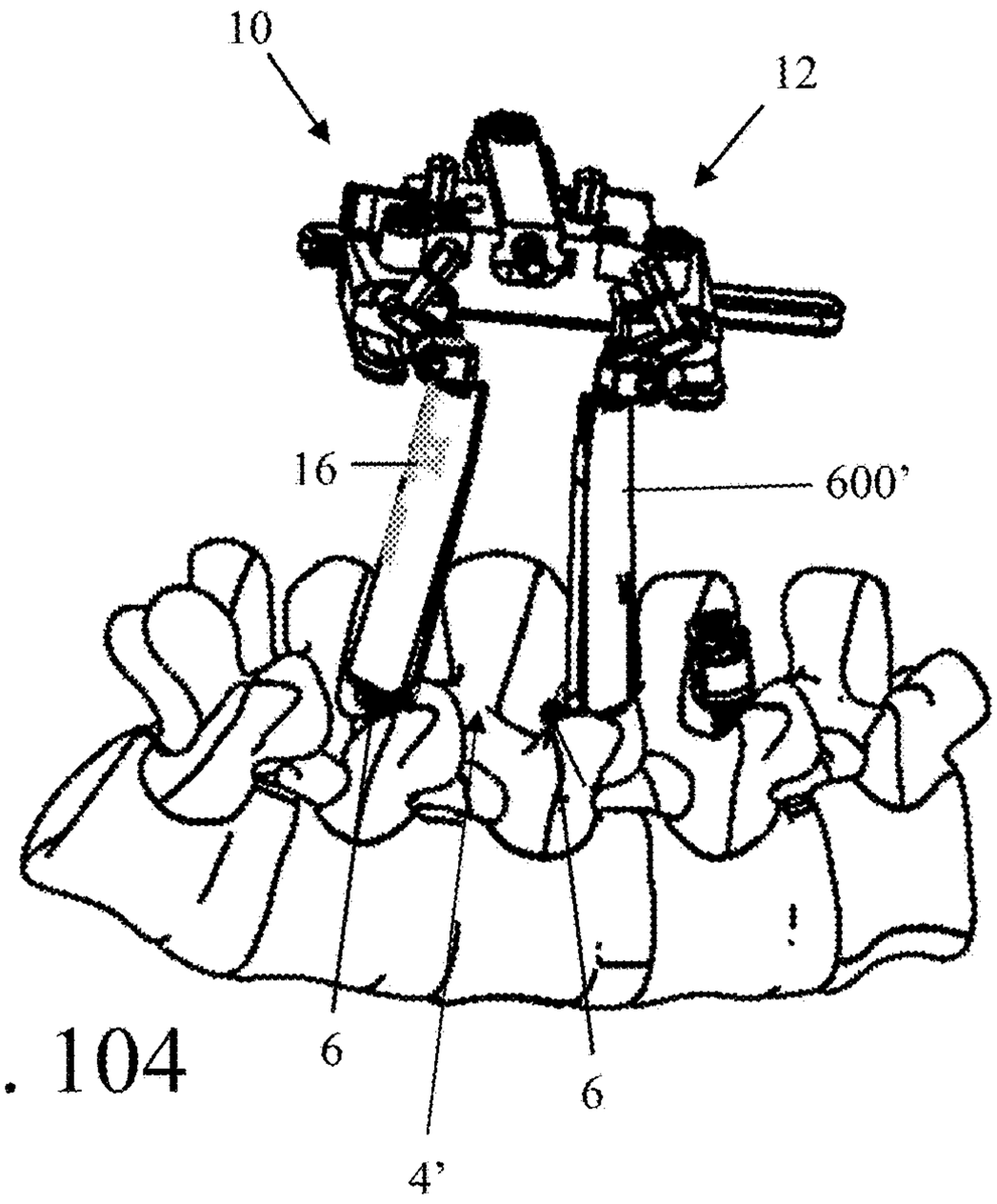


Fig. 104

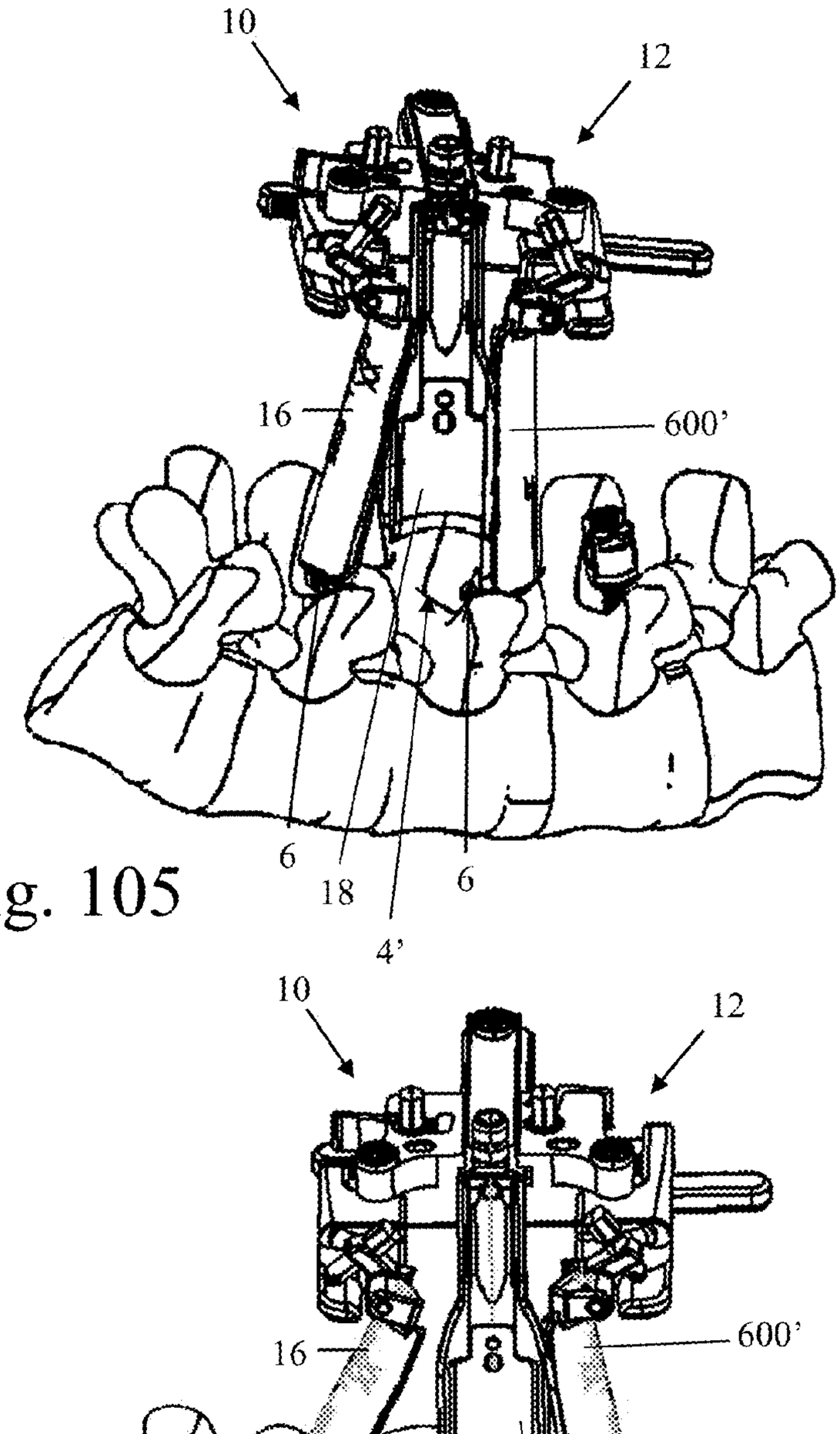


Fig. 105

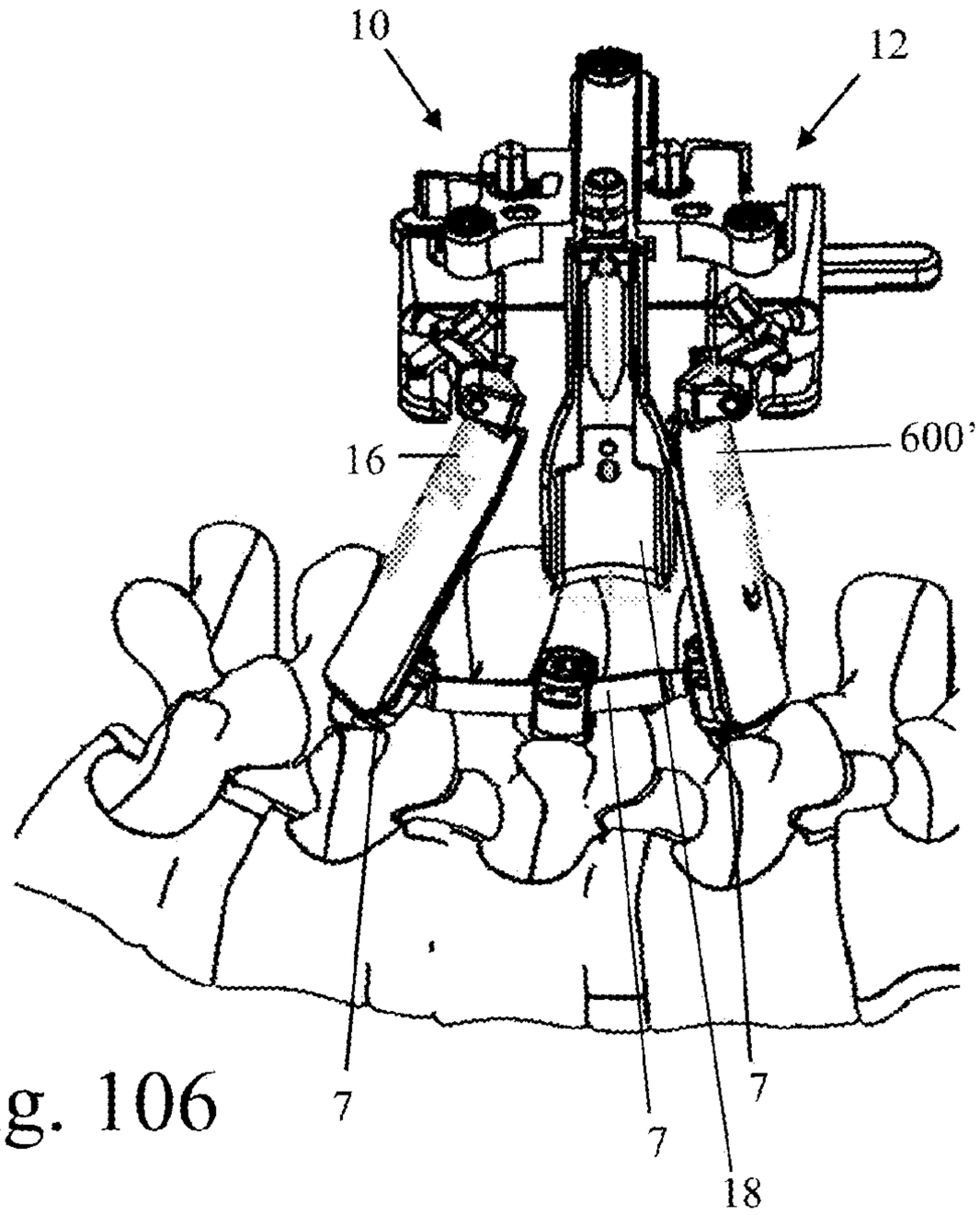


Fig. 106

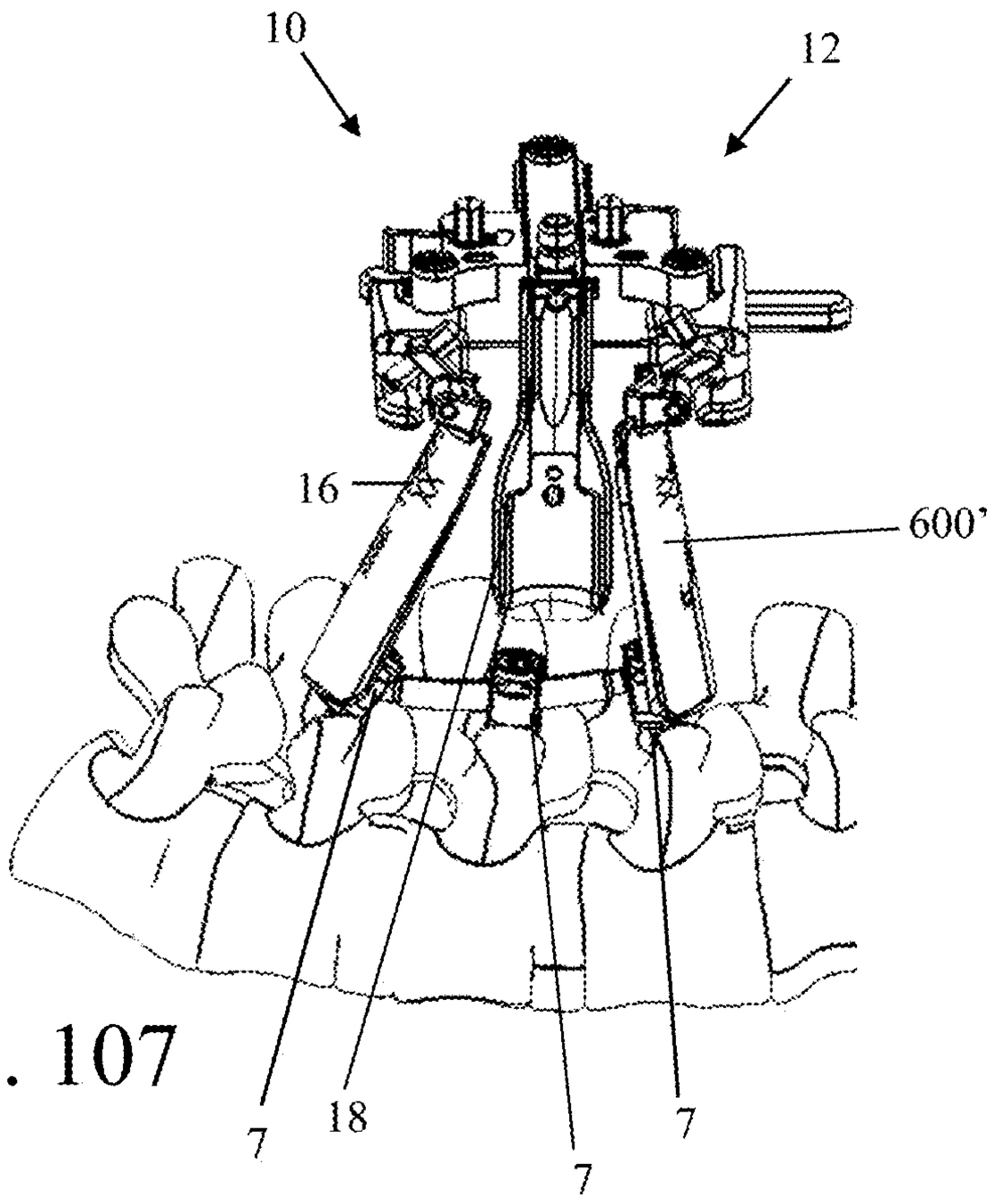


Fig. 107

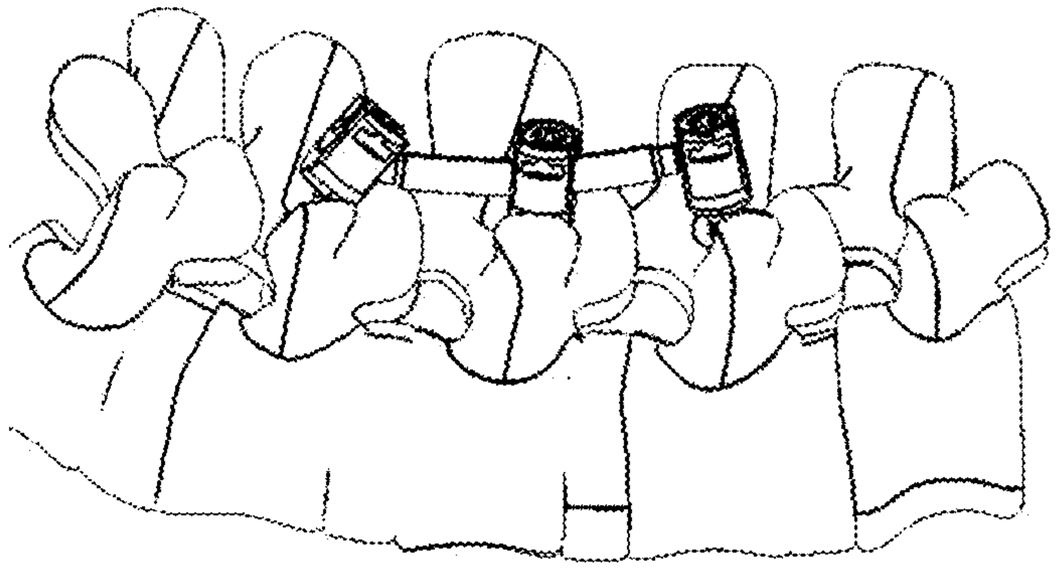


Fig. 108

METHOD AND APPARATUS FOR PERFORMING SPINAL SURGERY

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a division of U.S. patent application Ser. No. 14/029,724, filed Sep. 17, 2013; which is a continuation of Ser. No. 13/204,583, filed Aug. 5, 2011 (now U.S. Pat. No. 8,535,320), which is a continuation of U.S. patent application Ser. No. 12/927,415, filed on Nov. 10, 2010 (now U.S. Pat. No. 8,357,184), which claims the benefit of priority from U.S. Provisional Patent Application Ser. No. 61/259,825, filed Nov. 10, 2009. The contents of all of the foregoing are each incorporated herein by reference.

FIELD

This application relates to implants, instruments, and methods for performing surgical procedures on the spine, including one or more of creating an operative corridor to the spine, delivering implants to the spine, fusing one or more segments of the spine, and fixing one or more segments of the spine.

BACKGROUND

Spinal discs serve to cushion and stabilize the spine in addition to distributing stress and damping cyclic loads. The discs may become damaged due to injury or age and symptoms of a damaged disc may include severe pain, numbness or muscle weakness. Fusion is one method of reducing the magnitude of the symptoms of damaged spinal discs, or for any pathology that would suggest direct spinal decompression as a treatment. The primary goals of fusion procedures are to provide stability between the vertebrae on either side of the damaged disc and to promote natural fusion of those adjacent vertebrae. One of the most common fusion techniques utilized is the transforaminal lumbar interbody fusion (TLIF) in which the intervertebral disc space is accessed and operated on through a posterolateral approach. Generally, the TLIF procedure is performed through an "open" approach requiring a large incision and the separation and/or cutting of muscle and tissue, resulting in long recovery times and post-operative pain related to the procedure. To reduce the drawbacks associated with open procedures, minimally invasive techniques that reduce incision size and muscle cutting are becoming more popular. However, working through the smaller exposures brings other challenges, for example, decreased visualization and decreased flexibility in manipulating surgical instruments, among others, and thus the skill, training, and experience required for performing minimally invasive TLIF procedures is significantly higher than for open surgeries. A need therefore exists for improvements relating to the performance of minimally invasive TLIF procedures. The instruments and methods described herein are directed to addressing these needs.

SUMMARY

The present application describes implants, instruments, and methods for performing surgical procedures on the spine, including one or more of creating an operative corridor to the spine, delivering implants to the spine, fusing one or more segments of the spine, and fixing one or more segments of the spine.

According to one example, there is described a first method for attaching a fixation system to the spine of a patient. The fixation system includes at least two bone anchors and a spinal rod linking the at least two bone anchors. The method includes connecting a first bone anchor to a first retractor blade, advancing the first bone anchor and first retractor blade together to a first spinal bone, and anchoring the first bone anchor to the first spinal bone. The method also includes connecting a second bone anchor to a second retractor blade, advancing the second bone anchor and second retractor blade together to a second spinal bone, and anchoring the second bone anchor to the second spinal bone. The method also includes connecting a retractor body to the first retractor blade and the second retractor blade and operating the retractor body to expand an operative corridor formed between the first retractor blade and second retractor blade from the skin level of the patient to the spine. The method also includes linking the first bone anchor and the second bone anchor with a spinal rod.

According to another aspect of the first method the spinal bone is a first vertebra and the second spinal bone is a second vertebra separated from the first vertebra by an intervertebral disc space, and wherein the first spinal bone, second spinal bone, and intervertebral disc space comprise a first spinal level.

According to another aspect of the first method the first bone anchored is anchored through a pedicle of the first vertebra and the second bone anchor is anchored through a pedicle of the second vertebra.

According to another aspect of the first method, the method may further include adjusting the angle of the operative corridor.

According to another aspect of the first method, the first method may be performed wherein the angle of the operative corridor is adjusted until the operative corridor is parallel to the intervertebral disc space.

According to another aspect of the first method, adjusting the angle of the operative corridor is accomplished by moving a proximal end of the first retractor blade and a proximal end of the second retractor blade in the same direction while a distal end of the first retractor blade remains in the same general position adjacent the first pedicle and a distal end of the second retractor blade remains in the same general position adjacent the second pedicle.

According to another aspect of the first method the angle of the operative corridor is adjusted in one of a cephalad or caudal direction.

According to another aspect of the first method the angle of the operative corridor is adjusted in one of an anterior and posterior direction.

According to another aspect of the first method the angle of the operative corridor is adjusted in both one of a cephalad and caudal direction and in one of an anterior and posterior direction.

According to another aspect of the first method the first retractor blade is connected to the first bone anchor in a polyaxial engagement and the second retractor blade is connected to the second bone anchor in a poly axial engagement.

According to another aspect of the first method the first bone anchor is connected to the first retractor blade via a first hoop shim slidably engaged to an interior surface of said first retractor blade and the second anchor is connected to the second retractor blade by a second hoop shim slidably engaged to an interior surface of said second retractor blade.

According to another aspect of the first method each of the first hoop shim and the second hoop shim include a shim

portion that slidably engage the respective retractor blade and a hoop portion that receives a head a respective bone anchor therethrough.

According to another aspect of the first method each of the first hoop shim and the second hoop shim have an unlocked configuration that allows the head of the respective bone screw to pass therethrough and a locked configuration wherein the head of the respective bone screw is secured to the hoop shim.

According to another aspect of the first method the retractor body is further operated to distract the intervertebral disc space.

According to another aspect of the first method, the method may include advancing a third retractor blade towards the spine, connecting the third retractor blade to the retractor body, and operating the retractor body to expand the size of the operative corridor.

According to another aspect of the first method, the method may include advancing a third retractor blade towards the spine, connecting the third retractor blade to the retractor body, and operating the retractor body to further expand the size of the operative corridor.

According to another aspect of the first method the first and second retractor blades expand the operative corridor in cranially and caudally and the third retractor blade expands the operative corridor medially.

According to another aspect of the first method the third retractor blade clears tissue from the facet, lamina, and base of the spinous process as the third retractor blade retracted medially.

According to another aspect of the first method the third blade follows the topography of the facet, lamina, and base of the spinous process as the third retractor blade is retracted medially.

According to another aspect of the first method the third retractor blade includes a floating blade extension with a serrated distal end that curves to form a concave backward facing lip.

According to another aspect of the first method, the method may include applying downward pressure to the floating blade extension of the third retractor blade as the third retractor blade is retracted medially to facilitate clearing of the tissue from the facet, lamina, and base of the spinous process.

According to another aspect of the first method anchoring the first bone anchor to the first spinal bone comprises advancing a first anchor portion into said first spinal bone and subsequently attaching a first receiver portion to the first anchor portion and anchoring the second bone anchor to the second spinal bone comprises anchoring a second anchor portion to the second spinal bone and subsequently attaching a second receiver portion to the second anchor portion.

According to another aspect of the first method the first anchor portion is connected to the first retractor blade via a first hoop shim having a shim element that slidably engages the first retractor blade and a hoop element the secures the first anchor element, and wherein the second anchor portion is connected to the second retractor blade via a second hoop shim having a shim element that slidably engages the second retractor blade and a hoop element the secures the second anchor portion.

According to another aspect of the first method, the method may include removing the first hoop shim from the first anchor portion prior to attaching the first receiver to the first anchor portion and removing the second hoop shim from the second anchor portion prior to attaching the second receiver to the second anchor portion.

According to another aspect of the first method, the method may include operating on the first spinal level through the operating corridor prior to linking the first bone anchor and the second bone anchor with the spinal rod.

According to another aspect of the first method operating on the first spinal level includes one or more of a facetectomy, decompression, annulotomy, and discectomy.

According to another aspect of the first method at least a discectomy is performed and an implant is inserted into the intervertebral space after the discectomy.

According to another aspect of the first method the implant is positioned obliquely within the intervertebral space.

According to another aspect of the first method, the method may include operating the retractor body to distract the intervertebral disc space prior to performing the discectomy.

According to another aspect of the first method operating the retractor body to distract the intervertebral space includes advancing a first bolt disposed through a portion of the first retractor blade into contact with the retractor body to prevent inward tilting of the first retractor blade, advancing a second bolt disposed through a portion of the second retractor blade into contact with the retractor body to prevent inward tilting of the second retractor blade, and rotating a knob to increase the distance between a first arm of the retractor body engaged to the first retractor blade and a second arm of the retractor blade engaged to the second retractor blade.

According to another aspect of the first method the first retractor blade and the second retractor blade may be different lengths.

According to another aspect of the first method, the method may include connecting a third bone anchor to a fourth retractor blade, advancing the third bone anchor and fourth retractor blade together to a third pedicle adjacent the second pedicle, anchoring the third bone anchor to the third pedicle, and linking the third bone anchor together with the first bone anchor and second bone anchor with the spinal rod, wherein the third pedicle is part of a third spinal bone separated from the second spinal bone by a second intervertebral disc space, and wherein the second spinal bone, third spinal bone, and second intervertebral disc space comprise a second spinal level.

According to another aspect of the first method the steps of connecting a third bone anchor to a fourth retractor blade, advancing the third bone anchor and fourth retractor blade together to a third pedicle adjacent the second pedicle, and anchoring the third bone anchor to the third pedicle are performed after positioning the implant in the intervertebral disc space and before linking the first bone anchor, second bone anchor and third bone anchors with the spinal rod.

According to another aspect of the first method the first bone anchor includes a first anchor portion and a first receiver that is attached to the first anchor portion after the first anchor portion is anchored in the first pedicle, the second bone anchor includes a second anchor portion and a second receiver that is attached to the second anchor portion after the second anchor portion is anchored in the second pedicle, and the third bone anchor includes a third anchor portion and a third receiver that is attached to the third anchor portion after the third anchor portion is anchored in the third pedicle.

According to another aspect of the first method the first anchor portion is connected to the first retractor blade via a first hoop shim having a shim element that slidably engages the first retractor blade and a hoop element that secures the

first anchor element, wherein the second anchor portion is connected to the second retractor blade via a second hoop shim having a shim element that slidably engages the second retractor blade and a hoop element that secures the second anchor portion, and wherein the third anchor portion is connected to the fourth retractor blade via a third hoop shim having a shim element that slidably engages the fourth retractor blade and a hoop element that secures the third anchor portion.

According to another aspect of the first method, the method may include disconnecting the first retractor blade and the second retractor blade from the retractor body and reconnecting the retractor body to the second retractor blade and the fourth retractor blade and operating the retractor body to expand an operative corridor formed between the second retractor blade and the fourth retractor blade from the skin level of the patient to the spine.

According to another aspect of the first method the second retractor blade includes multiple connector elements such that the second retractor blade can be connected to the retractor body in both right-facing and left-facing directions.

According to another aspect of the first method, the method may include disconnecting the first retractor blade and the second retractor blade from the retractor body, replacing the second retractor blade with a fifth retractor blade, and reconnecting the retractor body to the fifth retractor blade and the fourth retractor blade and operating the retractor body to expand an operative corridor formed between the fifth retractor blade and the fourth retractor blade from the skin level of the patient to the spine.

According to another aspect of the first method replacing the second retractor blade with a fifth retractor blade includes the steps of removing the second retractor blade from a track insert connected to the second hoop shim and inserting the fourth retractor blade over the track insert.

According to another aspect of the first method, the method may include engaging a track guide to the track insert before removing the second retractor blade and inserting the fifth retractor blade along the track guide to facilitate engagement of the fifth retractor blade with the track insert.

According to another aspect of the first method, the method may include operating on the second spinal level through the operating corridor prior to linking the first bone anchor, second bone anchor, and third bone anchor with the spinal rod.

According to another aspect of the first method operating on the second spinal level includes performing one or more of a facetectomy, decompression, annulotomy, and discectomy.

According to another aspect of the first method at least a discectomy is performed and a second implant is inserted into the second intervertebral space after the discectomy.

According to another aspect of the first method a second implant is positioned obliquely within a second intervertebral space.

According to another aspect of the first method, the method may include operating the retractor body expand the operating corridor to reexpose the first bone anchor, disconnecting the second anchor portion and fifth blade, disconnecting the third anchor portion and fourth blade, and attaching the first receiver to the first anchor portion, attaching the second receiver to the second anchor portion, and attaching the third receiver to the third anchor portion, prior to linking the first bone anchor, second bone anchor, and third bone anchor with the spinal rod.

According to another example, there is described a second method for performing a spinal fusion procedure on a spinal segment of a human spine, the spinal segment including at least a first vertebra and a second vertebra separated from the first vertebra by an intervertebral disc space, including the steps of (a) anchoring a first anchor portion to a first pedicle, the first anchor portion being connected to a first retractor blade of a retractor assembly; (b) anchoring a second anchor portion to a second pedicle, the second anchor portion being connected to a second retractor blade of the retractor assembly; (c) connecting the first retractor blade to a first arm of a retractor body of the retractor assembly and connecting the second retractor blade to a second arm of the retractor body; (d) operating the retractor body to increase the distance between the first arm and the second arm to expand an operating corridor between the first retractor blade and the second retractor blade; (e) advancing a third retractor blade through the operative corridor to the spinal segment; connecting the third retractor blade to a translating arm of the retractor body, and operating the retractor body to translate the translating arm and further expand the size of the operating corridor; (f) preparing the intervertebral disc space to receive an implant; (g) implanting a fusion implant in the intervertebral disc space; (h) disconnecting the first retractor blade from the first anchor portion and attaching a first receiver portion to the first anchor portion; (i) disconnecting the second retractor blade from the second anchor portion and attaching a second receiver portion to the second anchor portion; (j) inserting and locking a rod into the first receiver portion and second receiver portion; and (k) removing the first and second retractor blades from the operative corridor and closing the operative corridor.

According to another aspect of the second method the first anchor portion is connected to the first retractor blade via a hoop shim slidably engaged with the first retractor blade.

According to another aspect of the second method the second anchor portion is connected to the second retractor blade via a hoop shim slidably engaged with the second retractor blade.

According to another aspect of the second method, the method may include connecting the first anchor portion to the first retractor blade by inserting a head of the first anchor portion into a hoop member of the hoop shim and engaging a shim element of the hoop shim to the first retractor blade and connecting the second anchor portion to the second retractor blade by inserting a head of the second anchor portion into a hoop element of a hoop shim and engaging a shim element of the hoop shim to the second retractor blade.

According to another aspect of the second method engaging a shim element of a hoop shim to one of the first and second retractor blades includes inserting the shim element into a track formed along an interior face of the retractor blade and sliding the shim element down the track until the shim element sits in a distal most position along the track.

According to another aspect of the second method stops at the distal end of the track prevent the hoop shim from disengaging the retractor blade from the distal end of the blade.

According to another aspect of the second method, may include manipulating the hoop shim connected to one of the first and second anchor portions into a locked configuration that prevents disassociation of the anchor portion and the hoop shim.

According to another aspect of the second method manipulating the hoop shim into a locked position includes slidably advancing a hoop portion of the hoop shim towards the shim element.

According to another aspect of the second method slidably advancing the hoop portion towards the shim element

causes a flange of the hoop portion to deflect inwards which causes a dimension of an anchor head receiving aperture in the hoop member to decrease.

According to another aspect of the second method the hoop shim is manipulated into the locked position after the hoop shim is inserted into a track formed along an interior face of one of the first and second retractor blades and advanced down the track to a distal end of the retractor blade.

According to another aspect of the second method may include connecting an inserter to the one of the first bone anchor first retractor blade and second bone anchor second retractor blade combinations

According to another aspect of the second method the shim elements slidably engage.

According to another example, a first system includes a retractor for performing and creating an operative corridor to a surgical target site is described. The system includes a retractor body which includes a first arm; a second arm, the first arm and the second arm being movable relative to each other in a first direction; and a center arm movable relative to the first arm and the second arm in a second direction orthogonal to the first direction; a first retractor blade attachable to first arm; a second retractor blade attachable to the second arm; and a third retractor blade attachable to the center arm, wherein the third retractor blade is pivotable relative to the center arm in the first direction.

According to another aspect of the first system the first and second retractor blades are registerable to first and second pedicle of the spine.

According to another aspect of the first system the first and second retractor blades are registerable to the spine via a poly axial engagement.

According to another aspect of the first system the poly axial engagement is with a hoop shim.

According to another example, a second system for creating an operative corridor to a surgical target site is described. The second system includes a retractor body, the retractor body including a first arm; a second arm, the first arm and the second arm being movable relative to each other in a first direction; and a center arm movable relative to the first arm and the second arm in a second direction orthogonal to the first direction. The second system also includes a first retractor blade attachable to first arm; a second retractor blade attachable to the second arm; and a third retractor blade attachable to the center arm, wherein a distal end of the first retractor blade is configured to be temporarily anchored in position relative to a first spinal bone and a proximal end of the first retractor blade is pivotable relative to the first arm, and wherein a distal end of the first retractor blade is configured to be temporarily anchored in position relative to a second spinal bone and a proximal end of the second retractor blade is pivotable relative to the second arm.

According to another example, a third system is described including a hoop shim for use with a surgical tissue retractor system. The hoop shim includes a shim portion having at least one feature that releasably associates with a retractor blade of the surgical retractor system; and a hoop portion having a hoop member that releasably associates with the head of a bone anchor.

According to another aspect of the third system the hoop portion and the shim portion are slidably engaged.

According to another aspect of the third system the hoop member extends orthogonally to the shim portion.

According to another aspect of the third system the hoop member has an unlocked position which allows passage of the bone anchor head and a locked position which prevents passage of the bone anchor head.

According to another aspect of the third system the shim portion and the hoop portion are slidably engaged and the locked position is entered by sliding the hoop portion towards a proximal end of the shim portion.

According to another aspect of the third system sliding the hoop portion towards the proximal end of the shim portion causes a dimension of an aperture formed through the hoop member to decrease in size.

According to another aspect of the third system the hoop portion includes a first flange and a second flange extending from the hoop member.

According to another aspect of the third system the first flange slides within a recess formed in the back of the shim element.

According to another aspect of the third system the first flange has a wing extension along at least portion of the first flange extending beyond a perimeter of the recess in the back of the shim element, the wing extension being receivable within a track groove of the retractor blade.

According to another aspect of the third system the second flange also slides within the recess formed in the back of the shim element.

According to another aspect of the third system the second flange includes a proximal portion having a first width and an intermediate portion having a width greater than the first width of the proximal portion.

According to another aspect of the third system the proximal portion always resides within the recess in the back of the shim element.

According to another aspect of the third system the intermediate portion resides outside the recess when the hoop portion is in the unlocked position and resides in the recess when the hoop portion is in the locked position.

According to another aspect of the third system the intermediate portion has a sloped upper surface that engages a knob situated at the entrance such that second flange deflects toward the first flange when the hoop portion slides into the recess.

According to another aspect of the third system deflection of the second flange causes a dimension of an aperture formed through the hoop member to decrease in size.

According to another aspect of the third system deflection of the second flange causes a slight rotation of the shim element relative to the first flange such that a distal end of the shim element flares out to the side opposite the first flange and such that a width between the distal end of a wing extension on the first flange and distal end of a wing extension on the shim element is greater than the width at an entrance between a first track groove and a second track groove of the retractor blade thereby preventing the hoop shim from being slidably engaged to the retractor blade when the hoop shim is locked.

According to another aspect of the third system the intermediate portion has bottom portion sloped in the opposite direction of the slopped top portion that permits the intermediate portion to slide out of the recess.

According to another aspect of the third system the bottom surface is steeper than the slope of the top surface.

According to another aspect of the third system the sloped top surface of the intermediate element is also concave.

According to another aspect of the third system the sloped bottom surface of the intermediate element is also convex.

According to another aspect of the third system the first flange includes a tab disposed through a slot formed in the shim portion.

According to another aspect of the third system a retaining plate on the tab fixes the hoop portion and the shim portion together.

According to another aspect of the third system the hoop member includes an insert.

According to another aspect of the third system the insert comprises a polymer material.

According to another aspect of the third system the polymer is polyetheretherkeytone.

According to another aspect of the third system when the hoop portion is releasably associated with the bone anchor, the association permits the bone anchor to angularly move relative to the hoop portion.

According to another aspect of the third system the association permits polyaxial angulation.

According to another aspect of the third system the polyaxial angulation encompasses 360 degrees.

According to another aspect of the third system the shim portion and the hoop portion are provided preassembled.

According to another aspect of the third system the shim portion has a horizontal slot formed near a proximal end.

According to another aspect of the third system the horizontal slot has a ramped back-facing surface.

According to another example, a fourth system is described including a retractor blade for use with a surgical tissue retractor system. The retractor blade includes an attachment portion, an upper blade portion that extends generally orthogonally from the attachment portion, and a lower blade portion that extends at an obtuse angle from the upper portion such that a distal end of the lower blade portion is offset from the plane of the upper portion.

According to another aspect of the fourth system the distal end of the lower portion is offset from the plane of the upper portion by approximately one-quarter inch.

According to another aspect of the fourth system the retractor blade is provided in multiple lengths and the angle at which the lower blade portion extends from the upper blade portion is varied to achieve a generally uniform offset.

According to another aspect of the fourth system the lower blade portion has a greater width than the upper blade portion.

According to another aspect of the fourth system the lower blade portion includes a free sliding blade extension.

According to another aspect of the fourth system the lower blade portion has a recess in which the free sliding blade extension slides.

According to another aspect of the fourth system the recess has an elongated central slot in which a guide extension of the blade extension is disposed.

According to another aspect of the fourth system the recess also includes side grooves in which the edges of the blade extension are received.

According to another aspect of the fourth system the length of the central slot determines the sliding distance of the blade extension.

According to another aspect of the fourth system the distal end of the blade extension is curved toward the exterior side of the retractor blade.

According to another aspect of the fourth system the distal end of the blade extension is also has a concave curve.

According to another aspect of the fourth system the edge of the distal end is serrated.

According to another aspect of the fourth system the attachment portion includes an engagement feature that pivotally engages a retractor body.

According to another aspect of the fourth system the engagement feature is a cylindrical aperture dimensioned to receive a cylindrical post of the retractor body.

According to another aspect of the fourth system the attachment portion includes a set screw extending into the cylindrical aperture to secure the retractor blade to the retractor body.

According to another aspect of the fourth system the attachment portion includes a second engagement feature that connects to an insertion handle.

According to another aspect of the fourth system the second engagement feature is a post with a tapered proximal end and a cylindrical groove that is configured to receive a coil spring that extends into in a cylinder dimensioned to receive the post.

According to still another example there is described a fifth system, the fifth system including an inserter for anchoring a bone anchor. The inserter includes a driver assembly having a driver shaft and a distal engagement feature that engages a drive feature of the bone anchor; and a blade engagement member that releasably engages a retractor blade of a retractor assembly.

According to another aspect of the fifth system the driver shaft freely rotates relative to the engagement member such that a retractor blade attached to the engagement member doesn't rotate with the bone anchor as the bone anchor is driven into bone.

According to another aspect of the fifth system the blade engagement member comprises a body with a pair of wing extensions that slidably engage a pair of track grooves along the interior face of the retractor blade.

According to another aspect of the fifth system the engagement member further comprises a deflectable tab configured to be received within notches in the retractor blade.

According to another aspect of the fifth system the system further comprises a receiver member that captures a head of the bone anchor.

According to another aspect of the fifth system the receiver member comprises a receptacle having deflectable flanges that deflect inward around the head of the bone anchor to secure the bone anchor to the receiver member.

According to another aspect of the fifth system a thumb wheel linked to the receiver member draws the deflectable fingers into a cylinder causing the fingers to deflect.

According to another aspect of the fifth system the distal engagement feature of the driver shaft is housed within the receptacle such that the distal engagement feature engages with the drive feature of the bone anchor head when the bone anchor head is secured in the receptacle.

According to another aspect of the fifth system the receptacle rotates with the driver shaft.

According to another aspect of the fifth system the driver shaft is cannulated.

According to another example there is described a sixth system including a bone anchor, a retractor blade, and a shim that can be assembled into an anchor-blade-shim assembly. The sixth system includes a bone anchor having an anchor portion that includes a partially spherical head; a retractor blade that is attachable to a retractor assembly, the retractor blade having a track including first and second track grooves formed in an interior face; and a shim that slidably engages the first and second track grooves such that it is advanceable down the track towards a distal end of the retractor blade and

securely engages the partially spherical head of the bone anchor in a polyaxial engagement.

BRIEF DESCRIPTION OF THE DRAWINGS

Many advantages of the present invention will be apparent to those skilled in the art with a reading of this specification in conjunction with the attached drawings, wherein like reference numerals are applied to like elements and wherein:

FIG. **1** is a perspective view of an example of a surgical fixation system according to one embodiment of the present invention;

FIG. **2** is an exploded perspective view of the surgical fixation system of FIG. **1**;

FIGS. **3-5** are front, perspective, and side views of the surgical fixation system of FIG. **1**;

FIG. **6** is a partially exploded perspective view of an example of a tissue retraction system forming part of the surgical fixation system of FIG. **1**;

FIG. **7** is an exploded perspective view of an example of a retractor body forming part of the tissue retraction system of FIG. **6**;

FIG. **8** is a front perspective view of the retractor body of FIG. **7**;

FIGS. **9-10** are front perspective and rear perspective views, respectively, of an example of a housing member forming part of the retractor body of FIG. **7**;

FIG. **11** is a top perspective view of the retractor body of FIG. **8** with the housing member removed;

FIG. **12** is a top plan view of an example of a rack member forming part of the retractor body of FIG. **7**;

FIG. **13** is a perspective view of the rack member of FIG. **12** with the second rack member removed;

FIG. **14** is an exploded perspective view of a first toggle forming part of the retractor body of FIG. **7**;

FIGS. **15-16** are top plan and perspective views, respectively, of a medial retraction member coupled with a second toggle, forming part of the retractor body of FIG. **7**;

FIG. **17** is an exploded perspective view of a second toggle forming part of the retractor body of FIG. **7**;

FIGS. **18-19** are perspective views of an example of first arm member forming part of the retractor body of FIG. **7**;

FIGS. **20-21** are perspective views of an example of a second arm member forming part of the retractor body of FIG. **7**;

FIGS. **22-25** are various plan views of an example of a retractor blade assembly forming part of the tissue retraction system of FIG. **6**;

FIG. **26** is an exploded view of the retractor blade assembly of FIG. **22**;

FIGS. **27-30** are front plan, perspective, rear perspective, and side plan views, respectively, of a medial retractor blade assembly forming part of the tissue retraction system of FIG. **6**;

FIGS. **31-34** are perspective, exploded perspective, rear plan, and top plan views, respectively, of an example of a hoop shim assembly forming part of the surgical fixation system of FIG. **1**, the hoop shim assembly shown in an unlocked position;

FIGS. **35-37** are front plan, side plan and top plan views, respectively, of the hoop shim assembly of FIG. **31** in a locked position and engaged to a bone anchor forming part of the surgical fixation system of FIG. **1**;

FIG. **38** is a front plan view of the hoop shim assembly of FIG. **31** being coupled to a retractor blade assembly of FIG. **22**;

FIG. **39** is a front plan view of the hoop shim assembly locked and engaged with the bone anchor of FIG. **35** coupled to a retractor blade assembly of FIG. **22**;

FIGS. **40-41** are perspective and side plan views, respectively, of an example of a hoop shim removal tool according to one embodiment of the present invention;

FIG. **42** is a side plan view of a distal engagement region forming part of the hoop shim removal tool of FIG. **40**;

FIGS. **43-45** are font plan, back plan, and side plan views, respectively, of the hoop shim assembly locked and engaged with the bone anchor of FIG. **35** coupled to a retractor blade assembly of FIG. **22**, and also coupled to the hoop shim removal tool of FIG. **40** prior to disengagement of the hoop shim assembly from the bone anchor;

FIG. **46** is a perspective view of the hoop shim assembly unlocked and disengaged from the bone anchor of FIG. **35** coupled to a retractor blade assembly of FIG. **22**, and also coupled to the hoop shim removal tool of FIG. **40** after disengagement of the hoop shim assembly from the bone anchor;

FIGS. **47-48** and **50-53** are perspective views of the surgical fixation system of FIG. **1** during different stages of use on a spinal segment;

FIG. **49** is a top plan view of the fully assembled surgical fixation system of FIG. **1**;

FIGS. **54** and **55** are front plan and perspective views, respectively, of the fully assembled surgical fixation system of FIG. **1** in use on a spinal segment, particularly illustrating the extreme angulation capability of the system;

FIG. **56** is the front plan view of the fully assembled surgical fixation system of FIG. **49** with the spinal segment removed;

FIG. **57** is a close-up plan view of the fully assembled surgical fixation system of FIG. **49**, illustrating in particular the lockability of the system in an extreme angulation state;

FIGS. **58-61** are perspective views of a locked hoop shim assembly and bone anchor combination of FIG. **35**, with the bone anchor implanted within a bony segment, illustrating in particular the polyaxial engagement between the hoop shim assembly and bone anchor;

FIGS. **62** and **63** are front plan and perspective views, respectively, of the tissue retraction system of FIG. **6** having retractor blades of different lengths;

FIG. **64** is a perspective view of an example of an inserter according to one embodiment of the present invention, coupled to a bone anchor and hoop shim assembly of FIG. **35** and retractor blade of FIG. **22**;

FIG. **65** is a perspective view of a distal region of the inserter, bone anchor, hoop shim assembly, and retractor blade combination of FIG. **64**;

FIG. **66** is a perspective view of the inserter of FIG. **64**;

FIG. **67** is an exploded perspective view of the inserter of FIG. **64**;

FIGS. **68-70** are plan, perspective, and sectional views, respectively, of a receiver member forming part of the inserter of FIG. **64**;

FIGS. **71** and **72** are perspective views of a distal end of a receiver assembly forming part of the inserter of FIG. **64**;

FIG. **73** is a perspective view of a receiver assembly forming part of the inserter of FIG. **64**;

FIG. **74** is a perspective view of a driver member forming part of the inserter of FIG. **64**;

FIG. **75** is a perspective view of a distal end of the driver member of FIG. **74**;

FIG. **76** is a perspective view of a distal end of the driver member of FIG. **74** coupled with the receiver assembly of FIG. **71**;

FIG. **77** is a perspective view of a distal end of the driver member of FIG. **74** coupled with the receiver assembly of FIG. **72**;

FIG. **78** is a perspective view of a blade engagement assembly forming part of the inserter of FIG. **64**;

FIG. **79** is a perspective view of an example of a hoop shim reattachment tool according to one embodiment of the present invention;

FIG. **80** is an exploded perspective view of the hoop shim reattachment tool of FIG. **79**;

FIG. **81** is a side cross-section view of the hoop shim reattachment tool of FIG. **79**;

FIG. **82** is an enlarged perspective view of the distal end region of the hoop shim reattachment tool of FIG. **79**;

FIG. **83** is a perspective view of the distal end of a light cable, according to one example embodiment of the present invention;

FIG. **84** is a perspective view of the distal end of the light cable of FIG. **83** engaged to the retractor blade of FIG. **22** and extending over the proximal end of the hoop shim of FIG. **31**;

FIG. **85** is a perspective view of a tissue shim according to one example embodiment of the present invention;

FIG. **86** is a perspective view of the tissue shim of FIG. **86** illustrating the manner in which the shim element of the hoop shim nestles between wings of the tissue shim;

FIG. **87** is a front view of an alternate retractor blade for use with the surgical fixation system of FIG. **1**, according to one example embodiment;

FIG. **88** is a front view of the retractor blade of FIG. **87** with a track insert removed;

FIG. **89** is a front view of a track insert forming part of the retractor blade of FIG. **87**;

FIG. **90** is a front view of the retractor blade of FIG. **87** with the hoop shim of FIG. **31** engaged;

FIG. **91** is a front view of the track insert of FIG. **90** with the hoop shim engaged and the remainder of retractor blade removed;

FIG. **92** is a perspective view of a guide instrument for use with the retractor blade of FIG. **87**, according to one example embodiment;

FIG. **93** is an exploded perspective view of the guide instrument of FIG. **92**

FIG. **94** is a perspective view of the distal end of the body portion of the guide instrument of FIG. **92**;

FIG. **95** is a perspective view of an actuator of the guide instrument of FIG. **92**;

FIG. **96** is a perspective view of the distal end of a driver of the guide instrument of FIG. **92**;

FIG. **97** is a perspective view of the housing forming part of the body portion of FIG. **94**;

FIG. **98** is a cross section view of the housing of FIG. **97** showing the actuator of FIG. **95** and the driver of FIG. **98** interacting therein;

FIG. **99** is a perspective view of the guide instrument of FIG. **92** engaged to the retractor blade and track insert of FIG. **87**;

FIG. **100** is an enlarged view of the distal end of the guide instrument of FIG. **92** engaged to the retractor blade and track insert of FIG. **87**; and

FIG. **101-108** are perspective view of the spinal fixation system of FIG. **1** including the retractor blade of FIG. **87** in use during various steps of a multi-level spinal fusion procedure.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Illustrative embodiments of the invention are described below. In the interest of clarity, not all features of an actual implementation are described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure. The systems and methods for performing transforaminal lumbar interbody fusion disclosed herein boast a variety of inventive features and components that warrant patent protection, both individually and in combination.

FIGS. **1-5** illustrate an example of a surgical fixation system **5** according to one embodiment of the present invention. The surgical fixation system **5** includes a variety of sub-components dimensioned to allow for retraction of a soft tissue in order to establish an operative corridor through a patient's skin to a surgical target site. By way of example only, the surgical target site referred to herein throughout is an intervertebral disc space situated between two adjacent vertebrae. Although particularly suited for use in lumbar spine fixation, it will be readily appreciated by those skilled in the art that the surgical fixation system of the present invention may be employed in any number of suitable orthopedic fixation approaches and procedures, including but not limited to anterior, posterior, lateral, anterolateral, posterolateral, cervical spine fixation, thoracic spine fixation, as well as any non-spine fixation application such as bone fracture treatment.

By way of example only, the surgical fixation system **5** includes a tissue retraction assembly **10**, a plurality of hoop shims **6**, and a plurality of bone anchors **7**. According to one broad aspect of the present invention, the tissue retraction system **10** includes retractor body **12**, a first retractor blade **14**, a second retractor blade **16**, and a third retractor blade **18** (also referred to herein throughout as the medial blade **18**). The retractor blades **14**, **16**, **18** may be provided in any size and shape suitable to establish and maintain an operative corridor to the surgical target site, however, certain benefits may be achieved utilizing one or more aspects of the various shaped retractor blades described, which features should be apparent from the discussion herein. The bone anchor **7** may be one of the type shown and described in U.S. patent application Ser. No. 12/820,136, filed Jun. 21, 2010 and entitled "Polyaxial Bone Screw Assembly," the entire contents are hereby incorporated by reference into this disclosure as if set forth fully herein.

The tissue retraction assembly **10** may be configured such that the retractor blades **14**, **16**, **18** may be advanced to the surgical target site individually (e.g. sequentially) or together (e.g. simultaneously). For example, for simultaneous advancement, two or more of the retractor blades **14**, **16**, **18** may be attached to the retractor body prior to advancement to a surgical target site. As will be explained by way of example in further detail below, the tissue retraction assembly **10** is particularly suitable for individual advancement of each blade **14**, **16**, **18** to a surgical target site. For instance, the first retractor blade **14** may be advanced through an incision and securely attached to a first bone segment within the surgical target site. The second retractor blade **16** may then be advanced through an incision and securely attached to a second bone segment within the surgical target site. Once the first and second retractor blades **14**, **16** are secured to the first and second bone segments, the retractor blades **14**, **16** may then be attached to the retractor

body **12**. Thereafter, the first and second retractor blades **14**, **16** may be further moved by the retractor assembly to a second "open" position to establish and maintain a second operative corridor (or working channel). This operative corridor may be variable in size and approach angle to the surgical target site, providing the ability to establish numerous custom working channels. The medial retractor blade **18** may then be attached to the retractor body **12** and used as desired.

Referring to FIGS. **6-8**, the retractor body portion **12** includes a housing member **20**, a rack member **22**, a medial retraction member **24**, a first retractor arm **26**, a second retractor arm **28**, a first toggle **30**, and a second toggle **32**. Broadly, the housing member **20** provides a scaffold to hold the various components together. The rack member **22** provides a mechanism to expand the operative corridor in a caudal-cranial direction by moving the retractor blades **14**, **16** toward or away from one another. The medial retraction member **24** provides a mechanism to expand the operative corridor in a medial direction by moving the medial retractor blade **18** away from the first and second retractor blades **14**, **16**. The first retractor arm **26** couples to the first retractor blade **14**, and as will be explained in detail below, is configured to enable the first retractor blade **14** to retract nearby soft tissue and/or distract the first bone segment. The second retractor arm **28** couples to the second retractor blade **16**, and is configured to enable the second retractor blade **16** to retract nearby soft tissue and/or distract the second bone segment. The first toggle **30** controls the caudal-cranial movement of the first and second retractor arms **26**, **28**, and therefore the first and second retractor blades **14**, **16**. The second toggle **32** controls the medial movement of the medial retraction member **24**, and therefore the medial blade **18**.

Referring now to FIGS. **9-10**, the housing member **20** has a front side **34**, a back side **36**, an upper portion **38**, and a lower portion **40**. The housing member **20** further includes a first recess **42** extending axially through the upper portion **38** from the front side **34** to the back side **36**. The first recess **42** is configured to receive the medial retraction member **24** therein. The first recess **42** include a pair of track grooves **44** that are configured to engage with flanges **110**, **112** on the medial retraction member **24** to secure the medial retraction member to the housing **20**. The first recess **42** further includes a tapered surface **46** extending from the front side of the first recess **42** toward the front side **34** of the housing member **20**. This tapered surface **46** enables medial-lateral angulation of the medial retraction member **24** while in a retracted position. The tapered surface **46** is flanked by a pair of curved surfaces **48** that enable caudal-cranial pivoting of the medial retraction member **24** while in a retracted position. The upper portion **38** further includes a second recess **50** and a third recess **52**, formed within the housing member **20** on either side of the first recess **42**. The second recess **50** is configured to receive the first toggle **30** therein. The second recess **50** is dimensioned to allow for movement of the toggle **30** therein to enable the toggle **30** to perform its function, which is explained in further detail below. The third recess **52** is configured to receive the second toggle **32** therein. The third recess **52** is dimensioned to allow for movement of the toggle **32** therein to enable the toggle **32** to perform its function, which is explained in further detail below. The upper portion **38** further includes at least one attachment member **53** dimensioned to enable attachment of the retractor body **12** to an articulating arm (not shown) within the operative field. This attachment to the articulating arm ensures that the surgical retraction system **10** is securely registered to the operating table. The upper portion may also be provided with at least one aperture **55** dimensioned to receive a tool (not shown) configured to allow the operator to alter the position of the retractor body **12** in order to adjust the angle of the operative corridor.

The lower portion **40** includes a first lumen **54** extending axially through the housing member **20** transverse to the first recess **42**. By way of example only, the first lumen has a generally rectangular cross-section and is configured to slideably receive the first rack member **58** therethrough. The lower portion **40** further includes a second lumen **56** extending axially through the housing member **20** transverse to the first recess **42** and parallel to the first lumen **54**. By way of example only, the second lumen **56** has a generally rectangular cross section and is configured to slideably receive the second rack member **60** therethrough.

FIG. **11** illustrates the retractor body **12** without the housing member **20** to provide a clear view of the rack **22**. Referring now to FIG. **12**, the rack **22** includes a first rack member **58** and a second rack member **60**. By way of example only, the first rack member **58** is an elongated axial member having a generally rectangular cross section and a first end **62**, a second end **64**, and an elongated body **66** extending therebetween. Although shown and described as generally rectangular, other cross sectional shapes are possible without departing from the scope of the present invention. The first rack member **58** is dimensioned to be slideably received within the first lumen **54** of the housing member **20**. The first end **62** is connected to the first retractor arm **26**. The first rack member **58** further includes a plurality of teeth **68** on one surface, the teeth being provided along substantially the length of the first rack member **58**. The teeth interact with the first toggle **30** to allow controlled caudal-cranial movement of the first retractor blade **14**, as will be described.

By way of example only, the second rack member **60** is an elongated axial member having a generally rectangular cross section and a first end **70**, a second end **72**, and an elongated body **74** extending therebetween. Although shown and described as generally rectangular, other cross sectional shapes are possible without departing from the scope of the present invention. The second rack member **60** is dimensioned to be slideably received within the second lumen **56** of the housing member **20**. The first end **70** is connected to the second retractor arm **28**. The second rack member **60** further includes a plurality of teeth **76** on one surface, the teeth being provided along substantially the length of the second rack member **60**. The teeth interact with the first toggle **30** to allow controlled caudal-cranial movement of the second retractor blade **16**, as will be described.

Referring to FIGS. **7** and **13-14**, the first toggle **30** includes an actuator **78**, a gear **80**, and a release member **82**. The actuator **78** includes a superior handle portion **84** that includes a friction feature that enables a user to grip and turn the handle portion **84**. By way of example only, the handle portion **84** is provided with a friction feature comprising a plurality of planar surfaces **86** (for engagement with a rotation handle), however other friction features are possible, for example ridges, knobs, dimples, and/or a material overlay such as rubber that provides for adequate gripping by a user. The actuator **78** further includes an inferior post **88** that extends away from the handle portion **84**. The inferior post **88** includes at least one generally planar surface **90** configured to mate with the planar surface **93** of the gear **80** and transfer the torque applied by a user to the handle portion **84** to the gear **80**, thus turning the gear **80**. The

inferior post **88** further includes a recess **92** for receiving a snap ring **95**, which functions to secure the first toggle **30** to the housing member **20**.

By way of example only, the gear **80** has a generally circular cross-section and includes a central lumen **91** extending therethrough and a plurality of teeth **94** in the form of vertical ridges distributed about the perimeter of the gear **80**. The central lumen **91** includes a planar surface **93** configured to mate with the planar surface **90** of the actuator **78** to transfer the torque applied by a user to the handle portion **84** to the gear **80**, thus turning the gear **80**. The teeth **94** of the gear **80** are configured to mate with the teeth **68**, **76** of the first and second rack members **58**, **60**. As shown by way of example in FIG. **12**, the first toggle **30** is positioned between the first and second rack members **58**, **60** such that the teeth **94** of the gear **80** simultaneously engages the teeth **68** of the first rack member **58** and the teeth **76** of the second rack member **60**. Thus, as the handle portion **84** of the actuator **78** is turned by a user, the gear **80** causes the first and second racks **58**, **60** to simultaneously move in opposite directions. For example, when the handle portion **84** is rotated in a clockwise direction, the first rack **58** will move in a cranial direction (assuming proper placement of the retractor relative to the spine) and the second rack **60** will move in a caudal direction. The effect of this movement is that the first retractor blade **14**, through its connection to the first arm **26** (which is connected to the first rack member **58**) will move in a cranial direction and the second retractor blade **16**, through its connection to the second retractor arm **28** (which is connected to the second rack member **60**) will move simultaneously in a caudal direction.

Referring again to FIGS. **7** and **13-14**, the release member **82** includes body **96**, a tab **98**, and a flange **100**. The body **96** is a generally circular member having a central lumen **102** extending therethrough. The central lumen **102** is dimensioned to receive the post **88** of the actuator **78**. The tab **98** extends radially from the body and functions as a manipulation point for the user. The flange **100** includes a ratchet member **104** that is dimensioned to interact with the teeth **68** of the first rack member **58**. The release member **82** further includes a spring **106** that biases the ratchet member **104** into an engaged position relative to the teeth **68**. Thus, as the gear **80** turns and the first rack member **58** moves, the ratchet member **104** clicks into engagement with each passing tooth **68**. Thus the ratchet member **104** provides for controlled translation of the first and second rack members **58**, **60**, and creating a customizable operative corridor established in incremental amounts. The ratchet member **104** further prevents unwanted migration of the first rack member **58** (and therefore the second rack member **60** as well) such that the desired operative corridor will not alter once established. The ratchet member **104** is configured to allow for unidirectional movement of the first rack member **58** relative thereto while the ratchet member **104** is engaged to the gear **80**. The ratchet member **104** effectively prevents counterclockwise turning of the handle member **84**. To contract the operative corridor, for example upon completion of the desired surgical procedure, the user activates the tab **98**, causing the ratchet member **58** to disengage from the teeth **68**. This allows for free (though still simultaneous) translation of the first and second rack members relative to the housing member **20**. That is, a counterclockwise turning of the handle member **84** will cause the first and second rack members **58**, **60** to translate in an opposite direction, such that the first retractor blade **14** will move in a caudal direction and the second retractor blade **16** will move in a cranial direction.

FIGS. **15-17** illustrate the medial retraction member **24** in greater detail. By way of example only, the medial retraction member **24** comprises a medial rack **108** dimensioned to fit in the first recess **42** of the housing member **20**. By way of example only, the medial rack **108** is an elongated axial member having a generally rectangular cross section. The medial rack **108** includes a first flange **110** and a second flange **112**, each extending the length of the medial rack **108** and dimensioned to engage the overhangs **44** of the first recess **42**. The first flange **110** includes a plurality of teeth **114** in the form of vertical ridges that are distributed along the length of the first flange **110**. The teeth **114** engage with the gear **124** of the second toggle **32** to enable movement of the medial rack **108**. The medial rack **108** further includes a post **116** extending axially from the front end of the medial rack **108**. The post **116** is configured for engagement with the medial blade **18**. The post **116** has an end portion **118** having a first diameter and a recessed portion **120** between the end portion **118** and the medial rack **108**, the recessed portion **120** having a reduced diameter relative to the end portion **118**. This configuration allows for engagement, for example a snap-fit engagement, with the medial blade **18**.

The medial rack further includes at least one attachment member **109** dimensioned to enable attachment of the medial retraction member **24** to an articulating arm (not shown) within the operative field. This attachment to the articulating arm ensures that the surgical retraction system **10** is securely registered to the operating table. The attachment member **109** on the medial retraction member **24** is structurally identical to, and performs the same function as, the attachment member **53** of the housing member **20** (FIGS. **10-11**). However, attachment to the attachment member **109** of the medial retraction member **24** provides an entirely different effect than attachment to the attachment member **53** of the housing member **20**. Specifically, attachment to the attachment member **109** registers the medial retraction member **24** to the articulating arm, and therefore the surgical table. In this state, the medial retraction member **109** is secured in place, and actuation of the toggle **32** will therefore cause the retractor body **12**, to move laterally relative to the patient. Conversely, when the articulating arm is attached to the attachment member **53** of the housing **20**, the housing **20** is secured in place relative to the operating table, the actuation of the toggle **32** will cause the medial retraction member **24** to move medially relative to the patient. This feature is advantageous in situations in which the medial blade **18** has been placed, but for some reason the surgeon would prefer to move the operative corridor laterally relative to the spine rather than medially.

Referring now to FIG. **7** in addition to FIGS. **15-17**, the second toggle **32** includes an actuator **122**, a gear **124**, and a release member **126**. The actuator **122** includes a superior handle portion **128** that includes a friction feature that enables a user to grip and turn the handle portion **128**. By way of example only, the handle portion **128** is provided with a friction feature comprising a plurality of planar surfaces **130**, however other friction features are possible, for example ridges, knobs, dimples, and/or a material overlay such as rubber that provides for adequate gripping by a user. The actuator **122** further includes an inferior post **132** that extends away from the handle portion **128**. The inferior post **132** includes at least one generally planar surface **134** configured to mate with the planar surface **127** of the gear **124** and transfer the torque applied by a user to the handle portion **128** to the gear **124**, thus turning the gear **124**. The inferior post **132** further includes a recess **136** for receiving

a snap ring **138**, which functions to secure the second toggle **32** to the housing member **20**.

By way of example only, the gear **124** has a generally circular cross-section and includes a central lumen **125** extending therethrough and a plurality of teeth **140** in the form of vertical ridges distributed about the perimeter of the gear **124**. The central lumen **125** includes a planar surface **127** configured to mate with the planar surface **134** of the actuator **122** to transfer the torque applied by a user to the handle portion **128** to the gear **124**, thus turning the gear **124**. The teeth **140** of the gear **124** are configured to mate with the teeth **114** of the medial rack member **108**. As shown by way of example in FIG. **15**, the second toggle **32** is positioned adjacent the medial rack member **108**. As the handle portion **128** of the actuator **122** is turned by a user, the gear **124** causes the medial rack **108** to translate in a medial (or lateral) direction. For example, when the handle portion **128** is rotated in a clockwise direction, the medial rack **128** will move in a medial direction (i.e. toward the spinal column, assuming proper placement of the retractor relative to the spine). The effect of this movement is that the medial retractor blade **18**, through its connection to the medial rack **108** will move in a medial direction, thereby retracting soft tissue and expanding the operative corridor. The medial rack **108** thus contributes to the customizable nature of the operative corridor.

The release member **126** includes body **142**, a tab **144**, and a flange **146**. The body **142** is a generally circular member having a central lumen **148** extending therethrough. The central lumen **148** is dimensioned to receive the post **132** of the actuator **122**. The tab **144** extends radially from the body and functions as a manipulation point for the user. The flange **146** includes a ratchet member **150** that is dimensioned to interact with the teeth **114** of the medial rack member **108**. The release member **126** further includes a spring **152** positioned between the tab **144** and the housing **20** that biases the ratchet member **150** into an engaged position relative to the teeth **114**. Thus, as the gear **124** turns and the medial member **108** moves, the ratchet member **150** clicks into engagement with each passing tooth **114**. Thus the ratchet member **150** provides for controlled translation of the medial rack member **108**, and creating a customizable operative corridor established in incremental amounts. The ratchet member **150** further prevents unwanted migration of the medial rack member **108** such that the desired operative corridor will not alter once established. The ratchet member **150** is configured to allow for unidirectional movement of the medial rack member **108** relative thereto while the ratchet member **150** is engaged to the gear **124**. The ratchet member **150** effectively prevents counterclockwise turning of the handle member **128**. To contract the operative corridor, for example upon completion of the desired surgical procedure, the user activates the tab **144**, causing the ratchet member **108** to disengage from the teeth **114**. This allows for free translation of the medial rack member **108** relative to the housing member **20**. That is, a counterclockwise turning of the handle member **128** with the ratchet member **150** disengaged will cause the medial rack member **108** to translate in an opposite direction (e.g. lateral direction, away from the spine.

FIGS. **18-19** illustrate the first arm member **26** in greater detail. The first arm member **26** includes a front body portion **160**, a rear body portion **162**, a first flange **164**, and a second flange **166**. The front body portion includes a front surface **168** and a top surface **170**. The front surface **168** includes an aperture **172** formed therein and extending into the front body portion **160**. The aperture **172** is dimensioned to receive the engagement post **230** of the first retractor blade **14** (FIG. **6**) to enable engagement of the first retractor blade **14** to the retractor body **12**. The top surface **170** includes a second aperture **174** configured to receive a set screw **176** (FIG. **7**). The set screw **176** functions to lock the engagement post **230** within the aperture **172**, preventing unwanted ejection of the first retractor blade **14** from the first arm member **26**. The rear body portion includes a lower-facing inside tapered surface **178** that allows the medial blade **18** to pivot within a plane that is transverse to the longitudinal axis of the medial rack member **108**. This pivoting enables intraoperative repositioning of the retractor body **12** relative to the surgical target site without the need to detach the retractor body **12** from the articulating arm. The net effect is to alter the approach angle of the operative corridor relative to the surgical target site.

The first flange **164** extends axially from the rear body portion **162** and includes a third aperture **180** and fourth aperture **182**. The third aperture **180** is configured to securely mate with the first end **62** of the first rack member **58** such that the first arm member **26** moves with the first rack member **58**. By way of example only, the first arm member **26** can be securely mated with the first rack member **58** by welding, adhesive, snap-fit, friction-fit, or any other suitable method. Alternatively, the first arm member **26** can be integrally formed with the first rack member **58** without departing from the scope of the present invention. The fourth aperture **182** is configured to allow passage of the second rack member **60** therethrough. The third and fourth apertures **180**, **182** are generally rectangular in shape, however other shapes are possible depending on the cross-sectional shapes of the first and second rack members **58**, **60**. The second flange **166** extends axially from the front body portion **160** and includes a generally planar upper surface **184** and a curved medial surface **186**. The second flange **166** interacts with the thumbscrew **240** of the first retractor blade **14** and functions as a shelf to enable the lockable adjusted angulation feature of the first retractor blade **14**, as well as an alternative distraction feature of the tissue retraction system **10**, each of which will be described in greater detail below.

FIGS. **20-21** illustrate the second arm member **28** in greater detail. The second arm member **28** includes a front body portion **190**, a rear body portion **192**, a first flange **194**, and a second flange **196**. The front body portion includes a front surface **198** and a top surface **200**. The front surface **198** includes an aperture **202** formed therein and extending into the front body portion **190**. The aperture **202** is dimensioned to receive the engagement post **230** of the second retractor blade **16** (FIG. **6**) to enable engagement of the second retractor blade **16** to the retractor body **12**. The top surface **200** includes a second aperture **204** configured to receive a set screw **206** (FIG. **7**). The set screw **206** functions to lock the engagement post **230** within the aperture **202**, preventing unwanted ejection of the second retractor blade **16** from the first arm member **28**. The rear body portion includes a lower-facing inside tapered surface **208** that that allows the medial blade **18** to pivot within a plane that is transverse to the longitudinal axis of the medial rack member **108**. This pivoting enables intraoperative repositioning of the retractor body **12** relative to the surgical target site without the need to detach the retractor body **12** from the articulating arm. The net effect is to alter the approach angle of the operative corridor relative to the surgical target site.

The first flange **194** extends axially from the rear body portion **192** and includes a third aperture **210**. The third aperture **210** is configured to securely mate with the first end **70** of the second rack member **60** such that the second arm

member **28** moves with the second rack member **60**. By way of example only, the second arm member **28** can be securely mated with the second rack member **60** by welding, adhesive, snap-fit, friction-fit, or any other suitable method. Alternatively, the second arm member **28** can be integrally formed with the second rack member **60** without departing from the scope of the present invention. The third aperture **210** is generally rectangular in shape, however other shapes are possible depending on the cross-sectional shapes of the second rack member **60**. The second flange **196** extends axially from the front body portion **190** and includes a generally planar upper surface **214** and a curved medial surface **216**. The second flange **196** interacts with the thumbscrew **240** of the second retractor blade **16** and functions as a shelf to enable the lockable adjusted angulation feature of the second retractor blade **16**, as well as an alternative distraction feature of the tissue retraction system **10**, each of which will be described in greater detail below.

The retractor blades **14**, **16** may be provided in any size or shape suitable to establish and maintain an operative corridor to the surgical target site. In one embodiment, the retractor blades **14**, **16** can be individually selected for appropriate length. Therefore, the retractor blades **14**, **16** can be of different lengths which gives the surgeon additional control over the shape and size of the operative corridor (as shown for example in FIGS. **62** and **63**). The retractor blades **14**, **16** may be provided having a generally arcuate cross-section to facilitate a circular or generally oblong surgical corridor. FIGS. **22-25** illustrate an example of a first retractor blade **14** according to the present invention. FIG. **26** is an exploded view of the first retractor blade **14**. For the purposes of illustration, the specific features of the invention will be described in relation to the first retractor blade **14**. However it should be understood that the features described in relation to first retractor blade **14** are the same for second retractor blade **16**, but provided in a mirror-image configuration. Thus, though the first and second retractor blades **14** and **16** are not strictly interchangeable, the features of each blade are virtually identical rendering a repeat discussion unnecessary as cumulative.

Referring now to FIGS. **22-26**, the first retractor blade **14** includes an attachment portion **220** and a blade portion **222** extending distally from the attachment portion **220**. The attachment portion **220** has a front side **224**, a back side **226**, and a top surface **227**. The back side **226** includes a first aperture **228** extending into the upper attachment portion **220** and configured to receive an engagement post **230** therein. The engagement post **230** is configured to mate with the aperture **172** of the first arm member **26** to couple the first retractor blade **14** with the retractor body **12**. Correspondingly, the engagement post **230** is configured to mate with the aperture **202** of the second arm member **28** to couple the second retractor blade **16** with the retractor body **12**. The attachment portion **220** further includes a pair of second apertures **232** extending through the attachment portion **220** parallel to one another and transverse to the first aperture **228**. The second apertures **232** are vertically offset from the first aperture **228** but are at least partially in communication with the first aperture **228**. The second apertures **232** are configured to receive pins **234** that operate to secure the engagement post **230** to the retractor blade **14** (explained in further detail below). The attachment portion further includes a flange **236** extending angularly (relative to the top surface **227**) therefrom, the flange **236** including an aperture **238** configured to receive a thumb screw **240** therein. The flange **236** and thumb screw **240** interact with the second flange **166** of the first arm member **26** to enable the lockable angulation feature of the first retractor blade **14**, as well as an alternate tissue distraction feature of the tissue retraction system **10**, as will be described in greater detail below. By way of example only, both the thumb screw **240** and aperture **238** include threads to enable a threaded engagement therebetween. However, other engagements are possible without departing from the scope of the present invention. By way of example only, the flange **236** is angularly offset from the top surface **227** within a range of 15 to 50 degrees, with the preferable angle being approximately 30 degrees. The thumbscrew **240** includes a head **241**, a shaft **243**, and a distal tip **245**. The head **241** is generally cylindrical in shape and includes a rotation feature that enables the user to rotate the thumb screw **240**. The rotation feature may be anything that is suitable to enable rotation of the thumb screw **240**, for example including but not limited to a socket **247** for receiving a driver as shown in FIGS. **22**, **23** and **26**, and/or an external planar surfaces **249** to provide gripping for a driver or a user's hand, as shown in FIGS. **24** and **25**.

The blade portion **222** extends distally from the attachment portion **220** and includes an outside surface **242**, an inside surface **244**, a first lip **246**, and a second lip **248**. The outside surface is a smooth arcuate surface configured to interact with the patient's soft tissue near the operative corridor. As best seen in FIG. **24**, the outside surface **242** extends from the attachment portion **220** at a non-orthogonal angle relative to the top surface **227**. Since much of the blade has a generally uniform thickness, the inside surface **244** extends from the attachment portion **220** at the same non-orthogonal angle relative to the top surface **227**. Thus, the effect is that the operative corridor is immediately established having a conical shape with no further adjustment of the tissue retraction assembly **10** required. Additionally, the blade portion **222** extends from the attachment portion **220** such that the blade face (i.e. inner surface **244**) is oriented orthogonal to the attachment portion **220**. Thus, when the retractor blade is attached to the retractor body **10**, the inside surface faces **244** the operative corridor at an angle rather than facing directly at the opposing blade, for example between 20 and 60 degrees). This orientation of the blade portion relative to the attachment portion helps optimize the shape (e.g. triangular) of the operative corridor. The inside surface **244** includes a plurality of notches or recesses **250** arranged in a linear alignment thereon, the notches or recesses **250** being configured to interact with the knob **498** of the inserter **400**, as will be described in further detail below. The blade portion **222** further includes a pair of track grooves **252** spaced apart from one another and extending the length of the inside surface **244**. The track grooves **252** are configured to slideably receive a shim attachment, for example the hoop shim **6** shown and described herein. It should be understood, however, that any suitable shim attachment may be used without departing from the scope of the present invention. At the distal end of each of the track grooves **252** there is a stop **254**, which interacts with the hoop shim **6** to prevent the hoop shim **6** from passing the stop **254** once it has been fully engaged to the retractor blade. The first lip **246** and second lip **248** comprise edges of the blade portion **222** and each extend along the length of the blade portion **222** from the attachment portion **222** to the distal end of the blade portion **222**. Notably, the first and second lips **246**, **248** are asymmetric relative to one another. For example, the first lip **246** has a concave portion **256** that allows for clearance of spinal anatomy during blade angulation.

Referring to FIG. **26**, the engagement post **230** includes a boss **258** and a post **260**. The boss **258** is generally cylindrical in shape and is dimensioned to be received within the aperture **172** of the first arm member **26** to couple the first retractor blade **14** with the retractor body **12**. The boss **258** includes a recess **262** formed therein, the recess **262** configured to receive at least a portion of the set screw **176** to securely engage the first retractor blade **14** to the retractor body **12**. The post **260** extends axially from the boss **258** and is configured to be received within aperture **228** of the first retractor blade **14**. The post **260** further includes a recess **264** formed therein, the recess **264** being sized and dimensioned to receive at least a portion of both pins **234** therein. The pins **234** extend transversely relative to the post **260**, and prevent undesirable uncoupling of the post **230** from the first retractor blade **14**. In practice, the retractor blade **14** (and retractor blade **16**) is provided with the post **230** already secured within the aperture **228** with the pins **234** in place. The pins **234** may be secured by any suitable method, including for example welding, that ensures that the pins **234** securely retain the post **230** within the aperture **238**. Although described herein as using a set screw **176** to secure the first retractor blade **14** (and/or second retractor blade **16**) to the retractor body **12**, any suitable attachment mechanism can be used without departing from the scope of the present invention. For example, a quick connection mechanism such as a snap fit engagement is possible, as is a friction engagement or an integral blade.

Referring to FIGS. **27-30**, the medial retractor blade **18** may be provided in any size or shape suitable to establish and maintain an operative corridor to the surgical target site. By way of example only, the medial retractor blade **18** includes an attachment portion **270** and a blade portion **272**. The attachment portion **270** includes a knob **274** and an aperture **276**. The knob **274** is configured to allow manipulation by a user, for example to change the angulation of the medial retractor blade **18**. The knob also connects to a manual insertion tool (not shown). By way of example, the manual insertion tool includes a cylinder with a canted coil received in a notch therein. In a natural position, the coil extends into the cylinder. The tapered end of the knob **274** deflects the canted coil as the knob passes. When the coil reaches the groove formed in the knob, the coil returns to the natural position and secures the blade to the manual inserter. The aperture **276** extends into the attachment portion **270** and is configured to receive the post **116** of the medial retraction member **24** therein to securely attach the medial retractor blade **18** to the retractor body **12**. The engagement between the medial retractor blade **18** and the post **116** is provided by way of example as a snap-fit engagement allowing for relative easy insertion and/or removal of the medial retractor blade **18**. However, other engagements are possible without departing from the scope of the present invention, including but not limited to using a set screw (e.g. through the knob **274** into the aperture **276**), friction engagement, or providing a medial retraction member with integral blade. This engagement allows a user to intraoperatively change the medial retractor blade **18**, for example to swap out a shorter blade for a longer blade, and vice versa.

The blade portion **272** includes an upper portion **280** and a lower portion **282**. The upper portion **280** is adjacent to the attachment portion **270** and extends generally orthogonally therefrom. The lower portion **282** is located distally of the upper portion **280** and is offset from the upper portion **280** such that it forms an obtuse angle with the upper portion **280** (best shown in FIG. **30**). By way of example only, the offset is such that the distal end of the lower portion **282** is offset from the plane of the upper portion **280** by approximately one-quarter of an inch. Depending upon the length of the blade portion **272**, the angle formed between the upper and lower portions **280**, **282** is variable to achieve this one-quarter inch offset. The lower portion **282** is wider than the upper portion to accommodate the retraction of a greater amount of the patient's soft tissue near the surgical target site. The lower portion **282** includes a recess **284** configured to receive a blade extension **290** therein. The recess **284** includes an elongated central slot **286** formed therein and configured to receive a guide extension **292** therein. The recess **284** may further include a pair of elongated lateral slot **288** formed therein on either side of the central aperture **286**.

A blade extension **290** may be provided to enhance the functionality of the medial retractor blade **18**. The blade extension **290** is received within the recess **284** and is coupled to the medial blade **18** by the fastener **292**. According to one embodiment, the blade extension **290** is slideably coupled to the medial blade **18**. To enable this slidable coupling, the fastener **292** is slideably received within the elongated central aperture **286**. The blade extension **290** includes a front surface **294** and a back surface **296**. In use, the blade extension **290** is oriented such that the front surface **294** faces the operative corridor, and the back surface **296** engages the patient's soft tissue. The blade extension **290** may be generally curved such that the front surface **294** has a concave curvature and the back surface **296** has a convex curvature or it may the front and back may be generally flat. The blade extension **290** further includes a distal anchor element **298** provided thereon. The distal anchor element **298** comprises a roughened surface including a series of ridges and spike members that enable the clearing away of soft tissue from the surgical target site. The distal anchor element **298** has two aspects of curvature. The first aspect of curvature is that the distal anchor element **298** curves toward the back surface **296**. The second aspect of curvature is that the front surface **294** maintains its concave curvature.

The result is that the distal anchor element **298** acts much the same way as a "boat anchor" in that it is capable of travelling along the surgical target site, displacing soft tissue until the distal anchor element **298** engages hard tissue such as bone. By way of example only, when used during a TLIF procedure such as the one described herein by example, the distal anchor element **298** advantageously removes soft tissue from the facet as it is being retracted, saving the surgeon from having to manually clean the facet. Due to its unique shape, the distal engagement element **298** will either penetrate the bone or become wedged underneath the bone. The blade extension **290** is slideably coupled to the medial blade **18** such that, upon tilting or other movement of the surgical retraction system **10**, the blade extension **290** will remain stationary relative to the bone segment while the medial retractor blade **18** moves relative to the blade extension **290**. The blade extension **290** is therefore capable of telescoping (i.e. extending or retracting) to conform to anatomy during retraction, both with and/or without manual adjustments from the surgeon. Thus, the blade elongates since it is secured distally at the bone and proximally at the retractor body **12**. In this manner, the surgeon is able to further optimize, customize, and alter the operative corridor without having to disengage the retractor and/or any blades, while ensuring the exposure at the surgical target site (the base of the operative corridor) does not change, and thereby preventing previously retracted soft tissue from entering the operative corridor under the blade. Optionally, the blade extension **290** may be mechanically biased toward the

extended position in order to ensure that its tissue clearing functionality is maximized. This may be accomplished, for example, by including a spring member (not shown) attached to the medial blade **18** and configured to bias the blade extension **290** in the distal direction.

FIGS. **31-34** illustrate an example of a hoop shim assembly **6** according to one embodiment of the present invention. The hoop shim assembly **6** includes a hoop portion **300** slideably engaged with a shim portion **302**. The hoop portion **300** includes a hoop member **304**, a first flange **306** and a second flange **308** extending proximally from the hoop member **304**. The hoop member **304** is a generally circular member having a central aperture **310** configured to receive a bone anchor **7** therein. The hoop member **304** has a first, unlocked position having a first diameter allowing passage of the bone anchor **7** therethrough. In this first position, the head of the bone anchor **7** may pass through, but with resistance. The hoop member **304** further has a second, locked position, having a second diameter that does not allow passage of the head of the bone anchor **7** therethrough. Thus, when the hoop member **304** is in the locked position, the bone anchor **7** is secured to the hoop shim **6**. As will be explained below, this secured engagement does not mean that the bone anchor **7** is immobilized—on the contrary it is a polyaxial engagement (as illustrated in FIGS. **58-61**). The hoop member **304** may be optionally provided with an insert **312** (FIGS. **35-37**) to provide protective interaction with the bone anchor **7**. More specifically, the insert **312** protects the neck of the bone anchor **7** from a metal-on-metal contact with the hoop shim **6**, which could ultimately weaken the bone anchor **7**. The insert **312** may be composed of any suitable materials, including but not limited to polyetheretherketone (PEEK).

The first flange **306** is generally elongated and extends generally perpendicularly in a proximal direction from the hoop member **304**. The first flange has a wing **314** extending at least partially along the length of the flange **306** from the proximal end toward the distal end. The wing **314** is dimensioned to engage one of the track grooves **252** of the first retractor blade **14** (and/or second retractor blade **16**) to enable slidable engagement of the hoop shim assembly **6** with the retractor blade **14** (as shown in FIG. **38**, for example). The first flange **306** further includes a tab member **316** projecting in a forward direction (i.e. same direction as the hoop member **304**). The tab member **316** is generally rectangular and configured to slidably engage the vertical slot **338** of the shim portion **302**. The tab member **316** has a generally U-shaped retaining pin **318** attached thereto that prevents the tab member **316** from becoming disengaged with the vertical slot **338** during use. By way of example only, the retaining pin **318** is welded to the tab member **316** during assembly of the hoop shim assembly **6**, however other attachment methods are possible without departing from the scope of the present invention. For example, the tab member **316** and retaining pin **318** may be integrally formed with one another and then welded onto the first flange **306**. Additionally, a retaining plate may be welded over the tab instead of the retaining pin.

The second flange **308** is generally elongated and extends generally perpendicularly in a proximal direction from the hoop member **304** opposite and generally parallel (in an initial position) to the first flange **306**. The second flange **306** has a distal portion **320**, a proximal portion **322**, and an intermediate portion **324** positioned between the distal portion **320** and proximal portion **322**. The distal portion **320** is attached to the hoop member **304**, and has a first width. The proximal portion **322** has a second width that enables the proximal portion **322** to pass the knob **346** of the shim portion **302** and into the recess **344** of the shim portion **302**. By way of example only, the first width is greater than the second width. The intermediate portion **324** has a third width that is greater than both the first and second widths, and a convex edge **326** extending from the proximal portion **322** to an apex **328**. The intermediate portion **324** further includes a concave edge **330** extending between the apex **328** and the distal portion **320**.

The shim portion **302** is a generally rectangular elongated member having a proximal end **332** and a distal end **334**. The shim portion **302** further includes a first wing **336** extending substantially the length of one side of the shim portion **302** (e.g. the side that corresponds to the second flange **308** of the hoop portion **300**). The first wing **336** is dimensioned to engage one of the track groove **252** of the first retractor blade **14** (and/or second retractor blade **16**) to enable slidable engagement of the hoop shim assembly **6** with the retractor blade **14** (as shown in FIG. **36**, for example). The shim portion further includes an elongated vertical slot **338** extending substantially the length of the shim portion **302**. The vertical slot **338** is configured to slidably receive the tab member **316** therein. The shim portion **302** further includes a horizontal slot **340** positioned near the proximal end **332**. The horizontal slot **340** is dimensioned to engage the distal projection **366** of the hoop shim removal tool **350**, as described below. The horizontal slot has a ramped surface **341** extending toward the proximal end **332** of the shim portion **302**. By way of example only, the vertical slot **338** and horizontal slot **340** are shown as one connected L-shaped aperture, however separate apertures are possible without departing from the scope of the invention. The shim portion **302** further includes a second wing **342** positioned near the proximal end **332** on the opposite side of the shim portion **302** from the first wing **336**. The second wing **342** is dimensioned to align with the wing **314** of the first flange **306** during use (as shown in FIG. **33**). The second wing **342** has the same function as the first wing **336**. The shim portion **302** further includes a recess **344** formed within the back side of the shim portion. The recess **344** is dimensioned to receive at least a portion of the second flange **308** of the hoop portion **300**, to enable the hoop shim **6** to transition to a locked position. The recess **344** also includes a knob **346** positioned at the distal end of the recess **344**. The knob **346** functions to reduce the width of the opening of the recess **344** to prevent easy disengagement of the hoop portion **300**.

In use, the hoop shim assembly **6** is preferably provided in a preassembled form in which the tab member **316** is engaged within the vertical slot **338** and the retaining pin **318** is welded to the tab member **316**, preventing disengagement of the tab member **316** from the vertical slot **338**. In the initial position, the proximal portion **322** of the second flange **308** is positioned within the recess **344** of the shim portion **302** and adjacent to the knob **346**. In this initial position, a bone anchor **7** may be loosely engaged to the hoop member **304**, within the central aperture **310**. To secure the bone anchor **7** to the hoop shim assembly **6**, the hoop shim assembly **6** is moved from its initial unlocked position to a final locked position. To achieve this, the first and second flanges **306**, **308** are slidably advanced proximally along the shim portion **302**. The convex edge **326** of the intermediate portion **324** of the second flange **308** includes a relatively gradual curvature. As the second flange **308** is advanced past the knob **346** and into the recess **344**, the interaction between the knob **346** and the convex edge **326** causes the second flange **308** to deflect toward the first flange **306**. The width of the intermediate portion is preferably such

that the intermediate portion still engages the inner wall of the recess and remains in the deflected position. The concave edge **330** has a relatively steep concave curvature, and thus the apex **328** will not reverse past the knob **346** absent sufficient applied force. Once the apex **328** is beyond the knob **346** and within the recess **344** of the shim portion **302**, the hoop shim assembly **6** is in a locked position, and the bone anchor **7** is successfully and securely engaged thereto (e.g. FIG. **44**).

This final, locked position is illustrated by way of example only in FIGS. **35-37**. The bone anchor **7** is positioned within the aperture **310** of the hoop portion **300**. An insert **312** is provided within the hoop member **304**. Notably, the head **8** of the bone anchor **7** is positioned proximally of the hoop member **304**, and in this position is unable to pass through the aperture. The threaded shank **9** of the bone anchor **7** extends distally of the hoop member **304**.

FIG. **38** illustrates a hoop shim assembly **6** engaged with a retractor blade **14**, in an unlocked position and without a bone anchor engaged thereto. FIG. **39** illustrates a hoop shim assembly **6** lockingly engaged to a bone anchor **7** and engaged with a retractor blade **14**. The hoop shim assembly **6** may be coupled with the bone anchor **7** and/or retractor blade **14/16** either before or during a surgical procedure. In one embodiment, the hoop shim assembly **6**, bone anchor **7**, and retractor blade **14** are provided in a pre-assembled state. In such an embodiment, the hoop shim assembly **6** is first coupled to a retractor blade **14** as described above, in an unlocked position. A bone anchor **7** is then introduced such that the neck region is within the central aperture **310**. At this point the engagement between the hoop shim assembly **6** and bone anchor **7** is unsecure. The hoop shim assembly **6** is then moved into a locked position, securing the bone anchor **7** therein. The bone anchor **7**, hoop shim assembly **6**, and retractor blade **14** may then be coupled to an inserter, for example such as the inserter **400** shown and described in relation to FIGS. **64-78** below, and advanced simultaneously through the operative corridor to the surgical target site. Alternatively, the bone anchor **7** may be placed within the surgical target site and then engaged with the hoop shim assemblies **6** by slipping the heads **8** of the bone anchors **7** within the central aperture **310** of the hoop shim assembly **6** and then locking the hoop shim assemblies **6**. Moreover, the hoop shim assembly **6** may be intraoperatively engaged and/or disengaged from an implanted bone anchor **7** within a surgical target site. This feature is advantageous in that it allows the operative corridor to be registered to an anatomical landmark, and also removed from that registration, for example if the user wanted to expand the operative corridor beyond the implanted bone anchors. A further advantage of this feature is that it allows for intraoperative exchange of retractor blades **14**, **16**, for example to swap out for a longer or shorter blade, without losing the ability to register the operative corridor to an anatomical landmark, and without changing the position of the retractor body **12**.

FIGS. **40-42** illustrate an example of a hoop shim removal tool **350** according to one embodiment of the present invention. The hoop shim removal tool **350** is a generally elongated instrument having a distal engagement member **352**, an intermediate shaft **354**, and a proximal slap hammer **356** attached thereto. The distal engagement member **352** includes a top panel **358**, a bottom panel **360**, and a base **362** positioned between the top and bottom panels **358**, **360** at the proximal end of the distal engagement member **352**. The top panel **358** has a distal portion **364** that extends beyond the end of the bottom panel **360**. The distal portion **364** includes a projection **366** configured to engage the horizontal slot **340** of the hoop shim assembly **6**. As illustrated in FIG. **42**, the projection **366** is oriented such that there is an acute angle formed between the projection **366** and the top panel **358**. The projection **366** further includes a ramped leading surface **367** configured to deflect off the shim portion **302** as the distal engagement member **352** is advanced into engagement with the shim portion **302**. The bottom panel **360** includes a pair of lateral wings **363** positioned on either side of the bottom panel **360**. The lateral wings **363** are dimensioned to engage the track grooves **252** of the first retractor blade **14** (and/or second retractor blade **16**) to enable slidable engagement of the hoop shim removal tool **350** with the retractor blade **14** (as shown in FIG. **43**, for example).

The slap hammer **356** includes a distal stop **368**, a proximal stop **370**, an elongated shaft **372** extending between the distal and proximal stops **368**, **370**, and a slapper **374** slidably positioned on the elongated shaft **372**. The slapper **374** is configured to slide along the elongated shaft **372** between the distal and proximal stops **368**, **370**. The slap hammer **356** is designed to allow a user to generate a tremendous force in the proximal or distal direction. For example, a user would grab the slapper **374** and exert a force in a proximal direction by "slapping" it against the proximal stop **370**.

FIGS. **43-46** illustrate the steps of using the hoop shim removal tool **350** to remove the hoop shim **6**. First, as illustrated in FIGS. **43-44**, the hoop shim removal tool **350** is slidably engaged to the retractor blade **14** as described above. The distal engagement member **352** is advanced along the retractor blade **14** until the projection **366** engages the locked hoop shim assembly **6**. As the projection **366** is being advanced over the shim portion **302** between the proximal end **332** and the horizontal slot **340**, the top panel **358** is outwardly displaced. As the projection **366** engages the horizontal slot **340**, the top panel **358** snaps back into place and a secure engagement is achieved between the hoop shim removal tool **350** and the hoop shim assembly **6**, as illustrated in FIGS. **44** and **45**. The user then slaps the slapper **374** against the proximal stop **370** to generate a proximal force on the shim portion **302** of the hoop shim assembly **6**. This force should be great enough to at least pull the knob **346** past the intermediate portion **324** of the second flange **306**, causing the hoop shim assembly **6** to return to its unlocked position. In the unlocked position, the aperture **310** has an increased diameter. Another slapping of the slapper **374** should supply enough force to pull the hoop member **304** past the head **8** of the anchor member **7**, thus disengaging the hoop shim **6** from the anchor member **7** (as shown in FIG. **46**) and retrieving the hoop shim assembly **6** from the retractor blade track. Of course, a single slapping of the slapper **374** may be sufficient to both unlock the hoop shim assembly **6** and disengage the hoop member **304** from the anchor head **7**. The retractor blade **14** is no longer registered to the anchor member in the surgical fixation site, but can rather move freely and/or be removed entirely.

Although the hoop shim removal tool **350** has been described by way of example with regard to a specific embodiment, other mechanisms are possible. For example, the slap hammer may be replaced by a Kerrision-style trigger without departing from the scope of the present invention.

The surgical retraction system **10** described herein may be used in a variety of different surgical techniques involving a variety of areas of the body. By way of example only, the surgical retraction system **10** is ideal for performing a novel procedure for performing a transforaminal lumbar interbody

fusion (TLIF) procedure on a human spine. For the purposes of illustration, the example technique will be explained with regard to a one-level TLIF, in which two adjacent vertebrae are fused across a single intervertebral space. However, it should be noted that the system and method disclosed herein may be suitable to be used on multiple vertebral levels without departing from the scope of the present invention. Moreover, the system and methods described herein may be used and/or adapted for use in a variety of different surgical techniques involving a variety of areas of the body without departing from the scope of the present invention.

Prior to performing this technique, the patient is positioned in the prone position, (i.e. on his/her stomach). The first step in the method is to locate the pedicles that will in part define the surgical target site. The next step is to create an incision in the patient's skin above the surgical target site (in this example, an intervertebral disc space between two adjacent vertebrae). Specifically, the incision should be made between the pedicles along the lateral border. K-wires are then placed via a jamshidi through the small incisions into the pedicles on adjacent vertebrae. To assist with this, the surgeon may use a navigated guidance system, for example one shown and described in commonly owned PCT Application Nos. PCT/US07/11962, entitled "Surgical Trajectory Monitoring System and Related Methods," filed May 17, 2007, and PCT/US08/12121, entitled "Surgical Trajectory Monitoring System and Related Methods," filed on Oct. 24, 2008, the entire contents of which are each incorporated by reference into this disclosure as if set forth fully herein. Once the K-wires are positioned properly within the target pedicles, the surgeon may create an initial surgical corridor through finger dissection. The distance from the vertebral body and surface of the skin is measured using a ruled dilator or another suitable instrument. Another tool may be used to measure the appropriate screw length by indicating how far into bone the K-wire has been advanced. The next step in the procedure is pilot hole formation. Navigated guidance and fluoroscopic imaging may continue to be used to help the surgeon ensure the proper approach and trajectory into the pedicles is being maintained. A cannulated tap is then passed over each of the K-wires to tap an appropriate sized pilot hole into each of the pedicles. Optionally, the cannulated tap may be substantially insulated and provided with an electrified tip, or alternatively a second insulated cannula may be provided while the tap is electrified, in order to enable pedicle integrity testing during pilot hole formation. This function is similar to the procedure shown and described in U.S. patent application Ser. No. 10/836,105, now issued as U.S. Pat. No. 7,664,544, filed Apr. 30, 2004, entitled "System and Methods for Performing Percutaneous Pedicle Integrity Assessments," the complete disclosure of which is hereby incorporated by reference into this document as if set forth fully herein. Once this is completed, the appropriate length of retractor blades **14**, **16** is selected and assembled with the hoop shim assembly **6**, an anchor member **7**, and inserter **400** as shown and described herein. This step is repeated for both the first and second retractor blades **14**, **16**.

Once the blade-shim-anchor assembly has been securely created, the anchor member **7** (with hoop shim **6** and first retractor blade **14** securely attached) is advanced through the initial operative corridor and driven into the pilot hole in a first of the adjacent pedicles. This process is repeated with the second retractor blade **16** assembly and the second pilot hole, until the first and second retractor blades **14**, **16** are protruding from the initial incision, with the distal ends of the blades being securely registered to the anchor members **7** via the hoop shim assemblies **6**. At this point, the first and second retractor blades **14**, **16** may be attached to the retractor body **14** as described above. The surgeon may then operate the retractor body **12** to cause the retractor blades **14**, **16** to move in cranial and caudal directions, respectively, at the skin level. Because the distal portions of the retractor blades **14**, **16** are securely (and polyaxially) registered to the implanted anchor members **7**, the anchor members **7** will not move. However, the angle of the retractor blades **14**, **16** relative to the anchor members **7** may be adjusted to a desired angle (for example as shown in FIG. **54**, and the operative corridor will be established. Once established, the retractor body **12** may be locked to an articulating arm (not shown) by either one of the attachment members **53** of the retractor body **12**, or attachment members **109** of the medial rack **108**. Using a suitable tool or a finger, the surgeon then releases soft tissue from the facet. A medial retractor blade **16** may then be inserted and retracted as desired and as described above. As mentioned previously, the medial retractor blade may operate to clear remaining soft tissue from the facet. The medial retractor blade **16** may be angled to match the operative corridor by pivoting the blade in a plane that is transverse to the longitudinal axis of the medial rack **108**. In this fashion, the entire operative corridor may be established at an angle that is suitable for superior access to the disc space.

At this point, the tissue retraction assembly **10** is positioned as shown by way of example in FIGS. **47-50**. The surgeon has established a primary operative corridor **4** to a surgical target site **1**, and has distinct landmarks (i.e. the implanted anchor members **7**) delineating the cranial and caudal boundaries of the relevant operative window (the respective pedicles of the superior and inferior vertebrae **2**, **3**). The surgeon can now perform the necessary steps to clean out the intervertebral disc space and perform the interbody fusion procedure. This example procedure continues with a facetectomy in which at least a portion of the facet joint is removed, allowing access to the intervertebral disc space. The disc space is prepared using techniques generally known in the art, including disc brushes, scrapers, etc. The interbody implant is then inserted into the cleaned out disc space. By way of example only this may include, but not be limited to, inserting one or more artificial or allograft implants within the intervertebral space. According to one example, the implant may be inserted and positioned obliquely across the disc space. If necessary, the surgeon may use the tissue retraction system **10** to distract the disc space without expanding the incision at the patient's skin and without any further instrumentation. This tissue distraction feature of the disclosed device is described in greater detail below.

After placement of the interbody implant, the distraction of the screws is released, and the hoop shim assemblies **6** are removed using the hoop shim removal tool **350** as described above. The surgeon then "opens" the retractor slightly in a caudal-cranial direction using the thumbscrews **240** on the blades (opposed to the rack assembly **22**) as described below to increase the space around the pedicle screws. The pedicle screw tulips are then inserted onto the pedicle screws (FIG. **51**). A posterior fixation rod is then placed within the tulips (FIG. **52**), followed by compression (if necessary) and locking of the rod. With the procedure completed, the retractor can be returned to a "closed" position and then removed from the patient, closing the operative corridor (FIG. **53**). The surgeon will then close the operative wound, completing the procedure.

The surgical fixation system **5** shown and described herein by way of example boasts a variety of advantageous features. An advantage of the present system is that it allows for intraoperative adjustment of the operative corridor, and in particular the angle of approach (in all directions) to the surgical target site with assurance that the exposure will not stray from the desired target site because the distal ends of the retractor blades **14**, **16** are fixed in position at the target site. This advantage is accomplished by one or more features of the present invention. For example, the retractor blades **14**, **16** that define the exposure are fixed to the target site with a polyaxial engagement (e.g. the hoops shim assemblies **6** have a polyaxial interaction with the bone anchors **7**). The retractor blades **14**, **16**, **18** are each capable of multiaxial movement relative to the retractor body **12**. The first and second retractor blades **14**, **16** are capable of being locked in an angulated position.

FIGS. **54-57** illustrate extreme angulation capabilities of the tissue retraction system **10**. Once the primary operative corridor has been established as described above, it may become necessary to alter the position of the operative corridor, for example to be able to access intervertebral disc material that otherwise would not be able to be accessed. With the tissue retraction system **10** disclosed herein the angle of the operative corridor **4** may be altered without changing the surgical window at the target site—only the approach angle changes. This is enabled by the multiaxial movement capabilities of the retractor blades **14**, **16**, **18**. In this context, "multiaxial" means having the ability to pivot in a number of different directions relative to an initial position along one axis (or in a single plane). For example, each of the retractor blades **14**, **16**, has the ability to pivot in both a caudal and cranial direction. Similarly, the medial blade **18** has the ability to pivot in a caudal and cranial direction. It is contemplated that the retractor blades **14**, **16**, **18** may also be capable of polyaxial movement. In this context, "polyaxial" means having the ability to pivot in a number of different directions relative to an initial position along a number of axes (or in a number of different planes). Thus, blades may also be provided with the ability to pivot in a medial and/or lateral direction, or in a generally arcuate manner without departing from the scope of the present invention. Similarly, the medial retractor blade **18** may also be provided with the ability to pivot in a medial and/or lateral direction, or in a generally arcuate manner without departing from the scope of the present invention.

As mentioned previously, the result of this pivoting is that the tissue retraction system **10** described herein is capable of establishing and maintaining an angled operative corridor **4** to a surgical target site. The tissue retraction system **10** is able maintain this angulation due to the thumb screws **240** that are provided on each of the retractor blades **14**, **16**. As described earlier in relation to FIGS. **22-26**, the flange **236** and thumb screw **240** of the first retractor blade **14** interact with the second flange **166** of the first arm member **26** to enable the lockable angulation feature of the first retractor blade **14**. Similarly, the flange **236** and thumb screw **240** of the second retractor blade **16** interact with the second flange **196** of the second arm member **28** to enable the lockable angulation feature of the second retractor blade **16**. In one embodiment, the aperture **238** on the flange **236** and the thumb screw **240** are both threaded such that there is a threaded engagement between the flange **236** and thumb screw **240**. As best illustrated in FIG. **57**, once a desired angulation of the first retractor blade **14** is established, the thumb screw **240** is rotated clockwise to advance the threaded shaft **243** through the threaded aperture **238** until the distal tip **245** of the thumb screw **240** engages the top surface **184** of the second flange **166**. At this point, the user stops rotating the thumb screw **240** and the first retractor blade **14** is prevented from pivoting in the opposite direction due to the threaded engagement of the flange **236** and thumb screw **240**, as well as the engagement between the distal tip **245** of the thumb screw **240** and the top surface **184** of the second flange **166**. This process is repeated for the second retractor blade **16**. For example, once a desired angulation of the second retractor blade **16** is established, the thumb screw **240** is rotated clockwise to advance the threaded shaft **243** through the threaded aperture **238** until the distal tip **245** of the thumb screw **240** engages the top surface **214** of the second flange **196**. At this point, the user stops rotating the thumb screw **240** and the second retractor blade **16** is prevented from pivoting in the opposite direction due to the threaded engagement of the flange **236** and thumb screw **240**, as well as the engagement between the distal tip **245** of the thumb screw **240** and the top surface **214** of the second flange **196**. The medial retractor blade **18** may be provided with a locking element or be allowed to freely pivot. However, once the first and second retractor blades **14**, **16** are locked in position, the operative corridor **4** is established and will not move whether or not the medial retractor blade **18** is locked in position.

FIGS. **58-61** illustrate the polyaxial engagement between the hoop shim assembly **6** and the anchor member **7**. Due to the unique structure of the hoop member **304** and the head **8** of the anchor element **7**, the hoop shim assembly **6** (and by extension the retractor blade **14/16**) is able to maintain secure engagement to the anchor element **7** at a variety of angulations, including variable angulations. For example the hoop member **304** fits securely but loosely over the head **8** of the anchor member **7** to allow for locking of the hoop shim assembly **6** to the anchor member **7** but also allowing for polyaxial engagement therewith. This interaction between the hoop member **304** and anchor member **7** will serve several functions. First it provides a temporary but secure attachment for the retractor blades **14/16** to help keep the operative corridor secure during the surgical procedure and act as fixed anatomical landmarks for the surgeon, provided the surgeon knows exactly where the bone anchors are placed. In other words, the operative window at the surgical target site will not move even if the position of the retractor body **12** were to move, or even if the angles of the blades **14/16** were to alter, because the blades **14**, **16** are registered to the anchor members **7**, which are already implanted in the bone. Secondly, this interaction provides a pivot point for the retractor assembly, allowing the surgeon to tilt the retractor assembly (and therefore the operative corridor) while maintaining the proper placement of the distal end of the operative corridor (e.g. the space between the anchor members **7**). Another benefit to this feature is that the retractor body **12** is always securely registered to the patient. Yet another benefit of this feature is that it enables multi-axial maneuverability of the retractor blades **14/16**. More specifically, each retractor blade is able to tilt in a caudal direction or cranial direction (or even medial or lateral directions) without adversely affecting the engagement between the hoop shim assembly **6** and the anchor member **7**.

A second advantage of the tissue retraction system **10** disclosed herein is that it functions not only as a soft tissue retractor but also may function as a distracter capable of moving the adjacent vertebrae apart in order to distract the intervertebral disc space in a caudal-cranial direction. There are at least two distinct ways in which this can be accom-

plished. The first is by locking the retractor blades **14**, **16** in a desired orientation as described above and then operating the first toggle **30** of the rack member **22** to cause the retractor blades **14**, **16** to move apart from one another, thereby distracting the disc space. With this first instance, there would necessarily be an expansion of the operative wound at the skin level, because the retractor body **12** is working to expand the entire operative corridor. The general shape of the operative corridor (e.g. angulation of the retractor blades **14**, **16**) remains constant but the width of the operative corridor expands.

The second, alternative method of distracting the disc space involves maintaining the first and second rack members **58**, **60** in a stationary position, and then using the thumb screws **240** on the first and second retractor blades **14**, **16** to cause the distal ends of the retractor blades **14**, **16** to migrate apart from one another. Since these distal ends are attached to the implanted bone anchors **7**, the result is a separation of the vertebral bodies. However, since the retractor body **12** remains constant, there is no enlargement of the surgical wound at the skin level. The general conical shape of the operative corridor itself changes, as the angulation of the blades **14**, **16** also changes. This type of distraction can potentially have less detrimental effect to the patient because the skin incision is relatively unaltered. Referring again to FIG. **57**, in order to accomplish this distraction, the user starts with the first and second retractor blades **14**, **16** locked in position such that the distal tip **245** of the thumb screw **240** of the first retractor blade **14** is engaged with the top surface **184** of the second flange **166** of the first retractor arm **26**, and the distal tip **245** of the thumb screw **240** of the second retractor blade **16** is engaged with the top surface **214** of the second flange **196** of the second retractor arm **28**. At this point, the user would rotate one or both of the thumb screws **240** in a clockwise direction (to enable increased distraction) or in a counterclockwise direction (to decrease the distraction).

For the sake of simplicity, this process will be further described in relation to the first retractor blade **14** only, however it will be understood that the process is the same for the second retractor blade **16** as well. As the user rotates the thumb screw **240** when the distal tip **245** is engaged with the top surface **184** of the second flange **166** of the first retractor arm **26**, flange **236** will effectively travel in a proximal direction relative to the shaft **243** of the thumb screw **240**, since the distal tip **245** is prevented from travelling in a distal direction by the second flange **166**. This causes the distal end of the retractor blade to swing outward, or away from the working channel. Since the distal end is engaged to a bone anchor **7** via a hoop shim assembly **6** as described above, the movement of the distal end of the retractor blade will cause the bony segment to be displaced in the same direction (away from the working channel). This causes distraction of the disc space. This process can be performed independently for each retractor blade **14**, **16**, thus enabling further customization of the operative corridor and/or surgical target site.

A third advantage of the tissue retraction system **10** described herein is the ability to intraoperatively exchange retractor blades **14**, **16**, **18**. For example, this may be useful in situations in which the user desires one blade to be longer than the other. FIGS. **62-63** illustrate option for different sized blades. Because the blades **14**, **16** are independently insertable, and are also inserted prior to the retractor body **12** being attached, an opportunity exists for a surgeon to elect multiple sized retractor blades depending upon the type of procedure to be performed. For example, if the surgeon is anticipating the need for extreme angulation in a particular direction, he or she may choose to use a longer retractor blade to accommodate for increased angle of one of the retractor blades. The interchangeability of the retractor blades allows for customization of the operative corridor.

FIGS. **64-67** illustrate an example of an inserter **400** for use with the tissue retraction system **10** of the present invention. As mentioned previously, the bone anchor **7**, hoop shim assembly **6**, and retractor blade **14** may then be coupled to an inserter, and advanced simultaneously through the operative corridor to the surgical target site. FIGS. **64** and **65** illustrate a bone anchor **7**, hoop shim assembly **6**, and retractor blade **14** coupled to the inserter **400**. In order to couple the various components together prior to insertion through an operative corridor, the first step is to slidably engage the unlocked hoop shim assembly **6** with the retractor blade **6** as described above. The bone anchor **7** is then loosely coupled with the hoop shim assembly **6**. The hoop shim assembly **6** is then locked with the bone anchor **7** engaged. The inserter **400** is then slidably engaged to the retractor blade **14** (as described below), advanced toward the bone anchor **7**, and then releasably coupled to the bone anchor as described below. Once this coupling has occurred, the insertion assembly is very secure due to the fact that each component (bone anchor **7**, hoop shim assembly **6**, retractor blade **14** and inserter **400**) is coupled to two other components at the same time. Specifically, the bone anchor **7** is coupled to the hoop shim assembly **6** and inserter **400**. The hoop shim assembly **6** is coupled to the bone anchor **7** and retractor blade **14**. The retractor blade **400** is coupled to the hoop shim assembly **6** and the inserter **400**. The inserter **400** is coupled to the bone anchor **7** and retractor blade **14**. The result is a secure and robust engagement that allows the user to safely advance the components to the surgical target site.

Referring to FIGS. **66** and **67**, the inserter **400** includes a receiver assembly **402**, a driver assembly **404**, and an engagement assembly **406**. Broadly, the receiver assembly **402** includes a receiver member **408**, an elongated shaft **410**, and a thumbwheel **412**, and functions to securely engage the exterior of the head **8** of the anchor member **7**. The driver assembly **404** includes cannulated driver **414**, a housing **416**, and a proximal engagement member **418**, and functions to engage the head of the bone anchor **7** and drive it into the bone. The engagement assembly **406** includes a blade engagement member **420** and functions to engage the inserter **400** and retractor blade **14**, as well as enable the locking of the head **8** of the anchor member **7** within the receiver assembly **402**.

Referring to FIGS. **68-70**, the receiver member **408** is a generally cylindrical member having a proximal end **424**, a distal end **426**, and a body **428** extending therebetween. The receiver member **408** further includes a central lumen **430** extending therethrough from the proximal end **424** to the distal end **426**. At the proximal end **424**, the central lumen **430** has a first diameter. At the distal end **426**, the central lumen **430** has a second diameter that is greater than the first diameter, forming a receptacle **432** configured to receive the head **8** of the anchor member **7** therein. The distal end **426** further includes a plurality of deflectable flanges **434** arranged radially about the distal end **426**. The deflectable flanges **434** include a raised surface **436** extending radially outward at the exterior of the distal end **426**. Within the central lumen **430**, the deflectable flanges **436** also include a concave surface **438** such that the opening **440** of the central lumen **430** has a smaller diameter than that of the receptacle **432**. The raised surfaces **436** interact with the distal aperture **494** of the engagement assembly **406** to cause

the flanges **434** to be deflected inward. This in turn causes the concave surfaces **438** to engage the neck **9** of the bone anchor **7**, thereby entrapping the head **8** within the receptacle **432**. The proximal end **424** further includes a plurality of apertures **442** formed therein, the apertures configured to receive connectors **452** at the distal end **446** of the shaft **410**. By way of example only, the receiver member **408** includes four apertures **442**, however, any number may be provided without departing from the scope of the present invention.

Referring to FIGS. **67**, **71** and **72**, the shaft **410** has a proximal end **444** and a distal end **446**. The proximal end **444** includes a threaded region **448** configured to threadedly engage the thumbwheel **412**, as will be described in further detail below. The shaft **410** is cannulated and therefore has a lumen **450** extending therethrough from the proximal end **444** to the distal end **446**. The lumen **450** is dimensioned to receive a K-wire (not shown) or similar guidance tool to guide the inserter **400** to the surgical target site during a surgical procedure. The distal end **446** includes a plurality of connectors **452** dimensioned to be received within the apertures **442** on the receiver member **408**. The connectors **452** snugly fit within the apertures **442** and are provided to prevent the receiver member **408** from rotating when the bone anchor **7** is being driven into bone.

The thumbwheel **412** has a lumen **454** extending axially therethrough and includes a pair of recesses **456** located on either end of the lumen **454** the recesses are each configured to receive a stopper **458** therein. The stoppers **458** are annular members that help hold the thumbwheel **412** in place and provide friction resistance to the thumbwheel **412** so that some force is required to turn the thumbwheel **412**. The lumen **454** is threaded to interact with the threaded region **448** of the shaft **410**. As will be explained below, the thumbwheel **412** is operable to cause the shaft **410** to translate proximally and distally, thereby causing the receiver member **408** to translate in and out of the distal aperture **494** of the engagement assembly **406**, and further causing the receiver member **408** to lock or unlock a head of an anchor member **7** therein. The thumbwheel **412** is further provided with a suitable friction engagement element **460**, for example ridges, recesses, bumps, adhesives, and the like, for enabling a user to grip and rotate the thumbwheel **412**.

Referring to FIGS. **67** and **73**, the housing **416** includes a proximal end **462**, a distal end **464**, and an aperture **466** positioned therein. The aperture **466** is dimensioned to receive the thumbwheel **412** and at least a portion of each of the stoppers **458**. The housing **416** is cannulated, having a lumen **468** extending therethrough dimensioned to receive the shaft **410** therein. The proximal end **462** includes a post **470** dimensioned to engage the proximal attachment member **418**. The distal end **464** includes a second post **472** dimensioned to engage the cannulated driver **414**. The proximal engagement member **418** extends proximally from the housing **416** and is configured to engage an attachment (e.g. a T-handle) that enables the application of torque by a user in order to drive a bone anchor **7** into bone.

Referring to FIGS. **74** and **75**, the cannulated driver **414** includes a proximal end **474**, a distal end **476**, and an elongated cylindrical shaft **478** extending therebetween. The cannulated driver **414** further includes a lumen **480** extending axially therethrough, the lumen **480** configured to receive the shaft **410** of the receiver assembly **402**. The distal end **476** includes a first cylinder **482** adjacent the shaft **478** and a second cylinder **484** extending distally from the first cylinder **482**. The first cylinder **482** is configured to engage the blade engagement member **406**. The second cylinder **484** has a diameter that is smaller than the diameter of the first cylinder **482**, and is configured to be at least partially received within the lumen **430** of the receiver member **408**. The second cylinder **484** includes a plurality of elongated slots **488** extending axially therethrough. The elongated slots **488** are provided in a number corresponding to the number of connectors **452** provided on the shaft **410**. By way of example, the second cylinder **484** includes four elongated slots **488**, however any number is possible. The elongated slots **488** each have width dimension corresponding to the diameter of the connectors **452**. The connectors **452** are slidably engaged within the elongated slots **488**, as illustrated by way of example in FIGS. **76** and **77**. The length of the elongated slots **488** determine the degree of translation of the shaft **410**, and thus the receiver member **408** that is allowed upon operation of the thumbwheel **412**.

Referring to FIG. **78**, the engagement assembly **406** includes a blade engagement member **420** and a cylindrical body **422**. The blade engagement member has a pair of elongated wings **490** that are configured to slidably engage the track grooves **252** of the first and/or second retractor blades **14**, **16**. The cylindrical body **422** includes a lumen **492** extending axially therethrough and a distal aperture **494**. The lumen **492** is dimensioned to receive the receiver member **408** and cannulated driver **414** therein. The aperture **494** is dimensioned to allow passage of the receiver member **408** therethrough. The blade engagement member **420** further includes an axially oriented deflectable flange **496** extending thereon, the deflectable flange **496** including a knob **498** configured to be received within the recesses **250** in the retractor blade **14**. When the knob **498** is positioned within a recess (or notch) **250**, the flange **496** is in a relaxed position. As the inserter **400** is being advanced along the retractor blade **14**, the knob **498** is forced out of the recess **250** and the flange **496** is deflected and under stress. When the knob **498** enters the next recess **250**, the flange **496** snaps back into its initial position. This provides both a tactile and audible indication of the sequential advancement of the knob **498** along the series of recesses **250**. In this manner, the user may be able to use the audible and tactile indications to determine how far the inserter **400** has been advanced along the retractor blade **14**.

In use, preferably the hoop shim assembly **6**, bone anchor **7**, and retractor blade **14** are coupled together as described above, with the hoop shim assembly **6** in the locked position. The inserter **400** is provided in an initial position, with the distal end **426** of the receiver member **408** protruding from the distal aperture **494** of the engagement assembly **406**. The inserter **400** is coupled to the retractor blade **14** via the engagement between the wings **490** of the engagement assembly **406** and the track grooves **252** of the retractor blade **14**. Once coupled to the retractor blade **14**, the inserter is slidably advanced along the retractor blade until the head **8** of the anchor member **7** is received within the receptacle **432** of the receiver member **408**. The opening **440** is slightly smaller than the diameter of the head **8** of the anchor member **7**, and thus there will be a tactile and/or audible indication as to when the anchor member **7** is received within the receiver member **408**. Once this indication is relayed, the user then turns the thumbwheel **412** to lock the head **8** within the receiver member **408**. Clockwise rotation of the thumbwheel **412** causes the shaft **410** (through the threaded engagement between the threaded region **448** of the shaft **410** and the threaded lumen **454** of the thumbwheel **412**) to migrate proximally through the inserter **400**. Due to the engagement between the connectors **452** and the receiver member **408**, a proximal migration of the shaft **410** causes a proximal migration of the receiver member **408**. This in

turn draws the distal end **426** of the receiver member **408** through the distal aperture **494** of the engagement assembly **406**. As this happens, the raised surface **436** interacts with the distal aperture **494** to cause the flanges **436** to be deflected radially inward. This causes the concave surfaces **438** to become engaged with the head **8** and/or neck **9** of the anchor member **7**, thereby securely locking the anchor member **7** to the inserter **400**. The assembly comprising the hoop shim assembly **6**, anchor member **7**, retractor blade **14**, and inserter **400** is now ready for use.

To disengage the inserter **400** from the anchor member **7**, the thumbwheel **412** is rotated in a counterclockwise direction. This rotation reverses the effects described above, and releases the inserter **400** from the anchor member **7**. The inserter **400** may then be slidably removed from the retractor blade **14**.

FIGS. **79-82** illustrate an example embodiment of a reattachment tool **500** for use with the tissue retraction system **10**. The reattachment tool **500** may be used to simplify the act of reattaching a hoop shim **6** (and retractor blade **14**, **16**) to the head of an implanted bone anchor **7**, in the event the hoop shim **6** becomes inadvertently or intentionally disengaged. For example, during the procedure the user may decide to swap out one or both of the retractor blades **14**, **16** with longer or shorter blades. To do this, the user the user may disengage the hoop shim **6** from the bone anchor **7**, with the hoop shim removal tool **350**. The hoop shim **6** and retractor blade **14**, **16** are removed from the operative corridor while the bone anchor **7** remains anchored. The new blade **14**, **16** and hoop shim **6** are engaged, as described above, with the hoop shim **6** in the unlocked position. The reattachment tool **500** is then engaged with the retractor blade **14**, **16** above the hoop shim **6** and the blade, hoop shim, and reattachment tool are advanced towards the bone anchor **7**. The hoop member is then attached over the bone anchor **7** and the hoop shim is locked.

The reattachment tool **500** includes an outer body **502**, an anchor engaging member **504**, a shim engaging member **506**, and a blade engaging member **508**. With reference to FIGS. **80-81**, the anchor engaging member **502** includes a shaft **510** terminating in a distal head **512** with a spherical pocket **514**. The anchor engaging member is spring loaded in a distal cavity **516** of the body **502**. The shaft **510** has a neck region **518** with a diameter that is larger than the rest of the shaft **510**. A spring **520** encircling the shaft **510** is captured between the neck **516** and a back wall **522** of the cavity **516**. A pin **526** traversing through cavity **516** prevents passage of the neck **518**, keeping the anchor engagement member **504** fixed in the body **502**. A cutout **526** between the distal head **512** and the neck **518** permits the anchor engaging member to slide along the pin **524** between a neutral position wherein the distal head **512** extends out of the body **502** and a depressed position wherein the distal head **512** is fully received within the body **512**. With the anchor engaging member **504** contacting the head **8** of bone anchor **7**, downward pressure is applied to the body **502** causing the distal head **512** of the anchor engaging member **504** to retract into the body **502** as the body **502** advanced towards the anchor site. The opening **528** at the distal end of the body **502** is large enough to receive the head **8** therein. As the head **8** is received into the body **502**, the distal end presses the hoop member **304** over the head **8**, such that the hoop shim **6** and bone anchor **7** are engaged in the unlocked position. The spherical pocket **514** of the distal head **512** complements the head **8** of the bone anchor **7** to help maintain engagement and alignment of the distal head **512** and anchor head **8**. A handle **530** is preferably included to facilitate use of the reattachment tool.

The shim engaging element **506** has a base **532** and an arm **534** ending in a pair of fingers **536**. The base **532** is spring loaded in a proximal cavity **536** of the body **502**. The arm **534** and fingers **536** extend along the outside of body **502**. Slot **538** in body **502** allows the base **532** and arm **534** to travel along the body **532**. A spring **540** is captured between a front wall **542** of the proximal cavity **536** and the base **532** and holds the shim engaging element **506** in a neutral position. Fingers **536** slidably engage the track grooves **252** of the retractor blade **14**, **16** and rest above the top of the shim element **302** of the hoop shim **6** when in the neutral position. Pusher **544** connects to the base **532** through a proximal end **548** of the body **502** and is used to advance the shim engaging element **506** distally towards the hoop shim **6**. After reengaging the hoop member **304** over the anchor head **8**, and with the distal end of the body still pressed against the hoop member **304** at the anchor site (and thus with the anchor head **8** still captured within the body **502**), the pusher is used to apply downward force to the shim element **302**, via the fingers **536**, to move the hoop shim into the locked configuration. The pusher **544** preferably includes an enlarged end **546** for easier use.

The blade engagement member **508** extends from the body **502** and includes a deflectable flange **550** extending thereon. The deflectable flange **550** includes a knob **552** configured to be received within the recesses **250** in the retractor blade **14**, **16**. When the knob **552** is reattachment tool **500** is being advanced along the retractor blade **14**, **16**, the knob **552** is forced out of the recess **250** and the flange **550** is deflected and under stress. When the knob **552** enters the next recess **250**, the flange **550** snaps back into its initial position. This provides both a tactile and audible indication of the sequential advancement of the knob **552** along the series of recesses **250**, as well as a secure (but releasable) engagement to the retractor blade **14**, **16**. The fingers **536** of the shim engaging element are situated on either side of the blade engaging element **508** and slidably engage the track grooves.

Turing to FIGS. **83-86**, the surgical fixation system described herein may be provided with a number of additional features or accessories. For example, as depicted in FIG. **83**, a light cable **554** capable of coupling to the retractor blade assemblies and illuminating the operative corridor without obstructing the surgeon's view may be provided. The light cable **554** has an offset distal end **556** and wing extensions **558** beginning proximally to the offset distal end. In this configuration the distal end **556** can slide over the shim element **302** when the light cable is advanced down the track grooves **252**, as shown in FIG. **84**. By extending the distal end **556** over the shim element **302** of the hoop shim, glare that might occur from light reflecting off of the shim element **302** is negated. An o-ring **560** disposed around the distal end **558** engages the slot **340** of the shim element **302** to secure the light cable **554** from unwanted movement. The light cable may be bendable but also capable of holding its bended such that the proximal portions can be bended out of the way after exiting the retractor blade.

By way of further example, tissue shims **562** are capable of coupling to the retractor blade assemblies to extend the width of the retractor blades. The tissue shims **562** include a blade engaging portion **564**. The blade engaging portion includes wing extensions (not shown) that slidably engage the track grooves **252** of the retractor blade **14**, **16**. A deflectable tab **566** similar those previously described

engages the notches **250** on the interior face of the retractor blades **14**, **16** to secure the position of the tissue shim **562** along the retractor blade. Branches **568** extend outward and downward from the blade engaging portion **564**, such that when the blade engaging portion **564** is slidably received down the track grooves **252** of the retractor blade **14**, **16**, the branches **568** extend down to the target site, or nearly so, while the blade engaging portion remains above the shim element **302** of the hoop shim **6**. The light cable **554** may be inserted above the tissue shim **562**.

Still by way of further example, though not shown, a fourth blade attachment may be provided that independently places a fourth retractor blade within the operative corridor opposite the medial retractor blade. The fourth retractor blade assembly may be attached to retractor body, medial blade assembly, or either of the first or second (or both) retractor blade assemblies. The fourth retractor blade may be attached to the retractor body so as to allow multi axial movement or polyaxial movement. The fourth retractor blade may be used to expand the operative corridor laterally to expose the transverse processes. The fourth retractor blade may be similar to the third retractor blade **18** described above. The blade extension of the fourth retractor blade may be free floating as described for retractor blade **18** or it may be fixed. In either case, it is intended that the distal end of the forth retractor blade may elevate tissue off of the bone as it is extend or swept laterally. Exposing the transverse processes in this manner may provide the ability to increase fusion of the adjacent vertebrae by fusing the transverse processes together.

According to yet still another example, a malleable wall barrier may be provided that can be inserted between the retractor blades and the surrounding soft tissue to help keep the soft tissue out of the operative corridor and surgical target site. This malleable barrier may be semi-rigid in that it can be formed to conform to a desired shape yet hold this shape under pressure from the surrounding tissue. It is contemplated that this malleable barrier be supported by the retractor blades, but not necessarily attached to them. The malleable barrier may also extend out of the operative corridor (out of the patient) and be capable of being "folded" to lie on the patient's skin so as to be out of the surgeon's way.

While the retractor system **10** and methods described above have been directed towards single level fusion, it is possible to perform multiple level fusions using the retractor system **10**. This may be accomplished in a number of different fashions. For example, the steps described above can be completed in the same fashion expect that the blade-shim-anchor assemblies are implanted in the pedicles of the vertebra at either end of the multi level spinal segment such that the operative corridor simply spans the entire segment. Alternatively, the operative corridor may be adjusted to expose each level of the multi level fusion sequentially. In this case, a third blade-shim-anchor assembly is advanced and anchored into the pedicle of the additional vertebra. For efficiency, this step may be performed at the same time the blade-shim-anchor assemblies are anchored to the first and second pedicles or it may be performed once the user is ready to begin work on the additional level(s). The hoop shim **6** is disengaged from the bone anchor **7** at the middle vertebrae of the segment and the retractor blade **14** or **16** is removed and replaced with a retractor blade **16** or **14**, respectively, that faces the opposite direction (and the added third retractor blade). In one example this may be accomplished using the reattachment tool **500** as described above. According to another example, an alternate retractor blade **600** may be provided to facilitate swapping of the left and right facing blade at the middle level.

FIG. **87** illustrates an alternate retractor blade **600** that may be used with the retractor assembly **10** to facilitate multilevel procedures. The retractor blade **600** is similar to blade **14**, **16** described above and includes an attachment portion **602** and a blade portion **604**. The attachment portion **602** is generally identical to the attachment portion **220** of retractor blade **14**, **16**, such that repeat discussion is unnecessary.

The blade portion **604** is also similar to the blade portion **222** of retractor blade **14**, **16** in that it extends distally from the attachment portion **602** and includes an outside surface **606**, an inside surface **608**, a first lip **610**, and a second lip **611**. The first lip **610** and second lip **611** comprise edges of the blade portion **604** and each extend along the length of the blade portion from the attachment portion **602** to the distal end of the blade portion **604**. The first and second lips **610**, **611** are asymmetric relative to one another. For example, the first lip **610** has a concave portion **613** that allows for clearance of spinal anatomy during blade angulation. The outside surface is a smooth arcuate surface configured to interact with the patient's soft tissue near the operative corridor. The outside surface **606** extends from the attachment portion **602** at a non-orthogonal angle relative to the top surface of the attachment portion. Since much of the blade has a generally uniform thickness, the inside surface **608** extends from the attachment portion **602** at the same non-orthogonal angle relative to the top surface. Thus, the effect is that the operative corridor is immediately established having a conical shape with no further adjustment of the tissue retraction assembly **10** required. Additionally, the blade portion extends from the attachment portion **602** such that the blade face is oriented orthogonal to the attachment portion **602**. Thus, when the retractor blade **600** is attached to the retractor body **10**, the inside surface **608** faces the operative corridor at an angle, for example between 20 and 60 degrees). This orientation of the blade portion relative to the attachment portion helps optimize the shape of the operative corridor.

Where the retractor blade **600** differs from the retractor blade **14**, **16**, is in that the inside surface **608** is not formed of a single surface, but rather it includes a track insert **612**. As best viewed in FIG. **88**, inner surface **608** has recess **614** which slidably receives the track insert **612** from the bottom of the blade portion. Edges **616** of the track insert **612** slide into grooves **618** formed in the sides of the recess **614**. A deflectable tab **620** extends into the recess **614** pointing upward. As the track insert **612** advances into the recess **614** it deflects the tab **620** allowing the insert **612** to pass. When the track insert **612** is fully inserted into the recess **614** it abuts an upper portion **622** such that the track insert **612** and upper portion form a generally flush inner face. Together, the upper portion **622** and track insert **612** also define track grooves **630** that slidably receive the shim element **302** (as well as the inserter **400**, reattachment tool **500**, light cable **554**, tissue shim **562**, and guide **650**, for example). The deflectable tab **620** aligns with a horizontal aperture **624** near the top of the track insert **612** when the track insert is fully inserted and the tab **20** returns to a natural position, catching the horizontal aperture like a hook such that the track insert cannot disengage from the recess **614**. The track insert includes stops **632** that prevent the hoop shim **6** from disengaging from the bottom. The upper portion **622** and the track insert **612** both include notches **626** that function like the notches **252** described above.

Initially, the hoop shim **6** and bone anchor **7** may be engaged to the retractor blade **600**, coupled to the inserter **400**, and implanted into the appropriate pedicle as described above for blade **14**, **16**. To replace the blade **600** with an opposite facing blade **600'**(or to simply change blades for a longer or shorter blade), rather than removing the hoop shim **6** and reattaching the hoop shim together with a new blade, as described above, the hoop shim **6** and track insert **612** remain attached to the bone anchor **7** (as in FIG. **91**) and a new retractor blade **600'** (having the desired new orientation or size) slides onto the track insert **612**.

With reference to FIGS. **92-100**, a guide instrument **650** according to an example embodiment is pictured. The Guide instrument functions to both disengage the track insert **612** from the deflectable tab **620** and to guide the new blade onto the track insert **612**. The guide **650** includes a driver **652**, an actuator **654**, and a body **656**. The body **656** has a generally tubular outer shaft **658** fitted with a handle **660** at the proximal end and a housing **662** at the distal end. The underside of the outer shaft **658** includes an engagement plate **664** that slidably engages the track grooves **630** of the blade portion **604**. The housing **662** holds the actuator **655** and has an opening **666** through the engagement plate **664**. The driver **652** has a knob **668** to facilitate rotation of the driver. The distal end **670** of the driver includes a projection **672**. By way of example, the projection shown has a generally half circle shape. The projection **672** is offset from the center of the distal end **670** such that rotation of the driver **652** causes the height of the projection **672** to change as it travels the circumference. The projection **672** extends into housing **662** and rests in slot **674** of the actuator **654**. As projection **672** travels along the circumference of the distal end **670**, it drives the actuator **654** up or down. When the actuator is forced to the bottom of the housing **662**, that is when the actuator is in a locked position, a horizontal extension **676** extends through the opening **666**. When fully engaged with the retractor blade **600**, the horizontal extension **676** aligns with the horizontal aperture **624** of the track insert. The horizontal extension **676** passes through the horizontal aperture **624**, deflecting the tab **620** inward and releasing the track insert **612** from the rest of retractor blade **600**. The blade **600** can then be removed by sliding the blade along the engagement plate **664**. The guide **650** remains in place and the replacement retractor blade **600'** slides down the engagement plate **664** onto the track insert **612**. Rotating the driver to the unlocked position draws the horizontal extension **676** into the housing **662** and the deflectable tab **620** replaces the horizontal extension in the horizontal aperture.

With reference now to FIGS. **101-108**, the surgical retraction system **10** is demonstrated in use for performing a multi level TLIF procedure. By way of example, the multi level procedure begins the same way as the single level procedure described above (except that the anchor-shim-blade combination for the third vertebra may be placed at the same time as the others) and with reference to FIGS. **47-57**. This description of the multi level procedure picks up after the user has completed work at the first level (e.g. performed a discectomy and implanted a fusion implant), but before the spinal rod is inserted connecting the anchors **7** (FIG. **51**). The hoop shim **6** is removed from the outer vertebra of the completed level, a bone anchor receiver is attached to anchor **7**, and the corresponding retractor blade **16** is removed. The guide instrument **650** is advanced down the track grooves of the middle blade (i.e. the retractor blade positioned over the center vertebra of the multi level segment) (FIG. **101**). When fully seated, the guide **650** is actuated to engage the horizontal extension **676** into the horizontal aperture **624** to disengage the tab **620**. With the tab **620** disengaged, the retractor blade **600** is removed leaving the track insert **612** and guide **650** attached to anchor **7** via the hoop shim **6** (FIG. **102**).

The new retractor blade **600'** is slidably engaged to the guide **650** and advanced into the operative corridor along the engagement plate **664** of the guide. When the retractor blade recess **614** of blade **600'** has fully received the track insert **612**, the guide **650** is actuated to release the deflectable tab **620**, locking the track insert **612** to the new blade **600'**. The guide **650** is then removed.

At this point, with the retractor blades **14**, **600'** protruding from the incision and the distal ends of the blades being securely registered to the anchor members **7** via the hoop shim assemblies **6**, the retractor blades **14**, **600'** may be attached to the retractor body **14** (FIG. **104**). The surgeon may then operate the retractor body **12** to cause the retractor blades **14**, **14**, **600'** to move in cranial and caudal directions, respectively, at the skin level. As previously described, because the distal portions of the retractor blades **14**, **600'** are securely (and polyaxially) registered to the implanted anchor members **7**, the distal end of the blades will not move. However, the angle of the retractor blades **14**, **600'** relative to the anchor members **7** may be adjusted to a desired angle and the new operative corridor will be established to the second spinal level. Once established, the retractor body **12** may be locked to an articulating arm (not shown) by either one of the attachment members **53** of the retractor body **12**, or attachment members **109** of the medial rack **108**. Using a suitable tool or a finger, the surgeon then releases soft tissue from the facet. A medial retractor blade **16** may then be inserted and retracted as desired (FIG. **105**). As mentioned previously, the medial retractor blade may operate to clear remaining soft tissue from the facet. The medial retractor blade **16** may be angled to match the operative corridor by pivoting the blade in a plane that is transverse to the longitudinal axis of the medial rack **108**. In this fashion, the entire operative corridor may be established at an angle that is suitable for superior access to the disc space.

At this point, with the new operative corridor **4'** established, and has distinct landmarks (i.e. the implanted anchor members **7**) delineating the cranial and caudal boundaries of the new operative window. The surgeon can now perform the necessary steps to clean out the intervertebral disc space and perform the interbody fusion procedure. As above, this may include a facetectomy in which at least a portion of the facet joint is removed, allowing access to the intervertebral disc space and a discectomy. The interbody implant is then inserted into the cleaned out disc space. By way of example only this may include, but not be limited to, inserting one or more artificial or allograft implants within the intervertebral space. According to one example, the implant may be inserted and positioned obliquely across the disc space. If necessary, the surgeon may use the tissue retraction system **10** to distract the disc space with the retractor body **12**.

After placement of the interbody implant, the distraction off the screws is released, and the hoop shim assemblies **6** are removed using the hoop shim removal tool **350** as described above. The surgeon then "opens" the retractor slightly in a caudal-cranial direction using the thumbscrews **240** on the blades (opposed to the rack assembly **22**) as described below to increase the space around the pedicle screws. The pedicle screw receivers or tulips are then inserted onto the pedicle screw and the retractor blade **600'** can be actuated to expand out to the first anchor of the first vertebra (preferably by splaying the distal portion of the

retractor blade to minimize expansion at the top of the operative corridor. A spinal fixation rod is then placed within the tulips, followed by compression (if necessary). With the procedure is completed, the retractor can be returned to a "closed" position and then removed from the patient, closing the operative corridor. The surgeon will then close the operative wound, completing the procedure.

Although described with respect to specific examples of the different embodiments, any features of the systems and methods disclosed herein by way of example only may be applied to any of the embodiments without departing from the scope of the present invention. Furthermore, procedures described for example only involving specific structure (e.g. vertebral bone) may be applied to another structure (e.g. femur) without departing from the scope of the present invention. While this invention has been described in terms of a best mode for achieving this invention's objectives, it will be appreciated by those skilled in the art that variations may be accomplished in view of these teachings without deviating from the spirit or scope of the invention.

One advantageous feature of the surgical fixation and retraction system described herein is the registration of the distal ends of the retractor blades **14**, **16** to the implanted bone anchors **7**. Although described herein by way example as using a hoop shim assembly **6** to accomplish this purpose, other attachment mechanisms are possible, including but not limited to sutures, cables, hooks, etc.

The example method of performing surgery described herein disclosed the use of an electrified tap, in order to enable pedicle integrity testing during pilot hole formation. However, the system described herein may be provided with additional features to enable pedicle integrity testing before, during, and after placement of the bone anchors within the pedicle. For example, using the electrified tap as described above is one way to test for pedicle integrity prior to placement of the bone anchors. However, the system may be equipped to continuously monitor for pedicle integrity during placement of the bone anchors as well. For example, the blade-anchor-shim-inserter assembly may be substantially insulated, either through an insulative coating or an external barrier (e.g. sheath, cannula, etc) such that only a portion of the bone anchor (e.g. the distal tip) is electrified to deliver stimulation to evoke an EMG response. EMG monitoring can be continuous to test for potential pedicle breach during placement of the bone anchors. Moreover, pedicle integrity can be further tested for upon final placement of the bone anchors.

Although shown and described herein in use with a specific example of a TLIF procedure on a human spine, the tissue retraction assembly herein may be used for a variety of different procedures involving any parts of the body. The surgical fixation system described herein is well suited for use in any procedure involving decompression using bone anchors. The surgical fixation system can be used for any type of bony fusion, including discectomy and fusion. Within the spine space apart from fusion, the tissue retraction system can be used to create an operative corridor to enable any type of procedure, including but not limited to vertebral augmentation and vertebroplasty.

By way of example only, the various components of the surgical fixation system described herein may be manufactured of any material suitable to achieve the goals of stability and rigidity, including the ability to use the blades to distract the bony segments. By way of example only, the retractor body and retractor blades are made of stainless steel, however any metallic substance is possible without departing from the scope of the present invention. Moreover, any part of the system described herein, including for example the retractor blades, may be composed of image-friendly material such as carbon fiber reinforced polymer (CFRP) or poly-ether-ether-ketone (PEEK) without departing from the scope of the present invention. The ability to intraoperatively switch out retractor blades may be advantageous in that one or more image-friendly retractor blades may be used to initially establish the working channel, and then be intraoperatively exchanged for a stainless steel retractor blade in the event that the surgeon wishes to use the blades to distract the disc space.

What is claimed is:

1. A retractor for creating an operative corridor to a surgical target, the retractor comprising:

a retractor body which includes a first arm and a second arm, the first arm and the second arm being movable relative to each other in a first direction;

a first retractor blade attachable to the first arm, the first retractor blade comprising a first blade proximal end attachable to the first arm, a first blade distal end, a first blade length, a first blade inside surface, and a first blade outside surface, wherein the first blade outside surface is a smooth continuous arcuate surface configured to interact with a patient's soft tissue, the first blade length is sufficient to extend through an operative corridor extending from a position outside the patient's skin to the patient's spine, the first retractor blade including

a first hoop extending orthogonally from the distal end of the first blade, configured to releasably couple to a partially spherical bone anchor head, and

a first locking mechanism configured to cause the first hoop to assume an unlocked position which allows passage of the bone anchor head and a locked position which prevents passage of the bone anchor head; and

a second retractor blade attachable to the second arm, the second retractor blade comprising a second blade proximal end attachable to the second arm, a second blade distal end, a second blade length, a second blade inside surface, and a second blade outside surface, wherein the second blade outside surface is a smooth continuous arcuate surface configured to interact with a patient's soft tissue, the second blade length is sufficient to extend through an operative corridor extending from a position outside the patient's skin to the patient's spine, the second retractor blade including

a second hoop extending orthogonally from the distal end of the second blade, configured to releasably couple to a partially spherical bone anchor head, and

a second locking mechanism configured to cause the second hoop to assume an unlocked position which allows passage of the bone anchor head and a locked position which prevents passage of the bone anchor head.

2. The retractor of claim **1**, comprising a third arm movable relative to the first arm and the second arm in a second direction orthogonal to the first direction; and a third retractor blade attachable to the third arm.

3. The retractor of claim **2**, wherein the third retractor blade is pivotable relative to the third arm.

4. The retractor of claim **3**, wherein the third retractor blade is pivotable relative to the third arm in the first direction.

5. The retractor of claim **2**, wherein the third blade comprises a distal anchor element.

6. The retractor of claim 5, wherein the distal anchor element is selected from the group consisting of: a series of ridges, a series of spike members, and a combination of the foregoing.

7. The retractor of claim 1, wherein at least one of the first and second retractor blades is capable of multiaxial movement relative to the retractor body.

8. The retractor of claim 7, wherein the first and second retractor blades are capable of multiaxial movement relative to the retractor body.

9. The retractor of claim 7, wherein at least one of the first and second retractor blades is configured to pivot in both a caudal and cranial direction.

10. The retractor of claim 9, wherein the first and second retractor blade are configured to pivot in both a caudal and cranial direction.

11. The retractor of claim 1, wherein at least one of the first and second retractor blades is capable of polyaxial movement relative to the retractor body.

12. The retractor of claim 11, wherein each of the first and second retractor blades comprises a generally arcuate cross section.

13. The retractor of claim 1, wherein the first retractor blade is attached to the first arm, and the second retractor blade is attached to the second arm.

14. The retractor of claim 1, comprising a first bone anchor connected to the first hoop and a second bone anchor connected to the second hoop.

15. The retractor of claim 1, wherein said retractor is configured to advance to the surgical target site sequentially or simultaneously.

16. The retractor of claim 1, wherein the body comprises a rack connected to the first and second arms and configured to slide the first arm and the second arm relative to one another in the first direction.

17. The retractor of claim 16, wherein said rack includes: a first elongated axial rack member having a first plurality of teeth slidably engaged to the body; and a second elongated axial rack member having a second plurality of teeth slidably engaged to the body.

18. The retractor of claim 17, wherein the first elongated axial rack member is connected to the first arm.

19. The retractor of claim 17, wherein the second elongated axial rack member is connected to the second arm.

20. The retractor of claim 1, wherein the body comprises a first toggle to lock and unlock the ability of the first arm and the second arm to move in the first direction relative to one another.

21. The retractor of claim 1, wherein:

the first hoop in the unlocked position has an unlocked width allowing passage of the bone anchor head;

the first hoop in the locked position has a locked width disallowing passage of the bone anchor head;

the second hoop in the unlocked position has an unlocked width allowing passage of the bone anchor head; and

the second hoop in the locked position has a locked width disallowing passage of the bone anchor head.

* * * * *